Iowa DOT Linear Referencing Development Project

Iowa Department of Transportation

GeoAnalytics

TRANSDECISIONS

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Session Agenda

- Quick Overview
- Field Pilot Results
- LRS Data Model
- System Architecture & Technology
- Future Direction
- Questions

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Presenters

- Bill Schuman - Iowa Department of Transportation
- Tom Ries - GeoAnalytics, Inc.
- Julian Ray – TransDecisions, Inc.

- Many other valuable contributors to the project

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A Quick NCHRP 20-27 and Project Review

Bill Schuman

Iowa DOT

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A couple definitions...

- LRM - Linear Referencing Method
  - » Different methods of measuring linear locations; (i.e. milepost, stations, etc.)
- LRS - Linear Referencing System
  - » a set of procedures and methods for specifying a location as a distance, or offset, along a linear feature, from a point with known location

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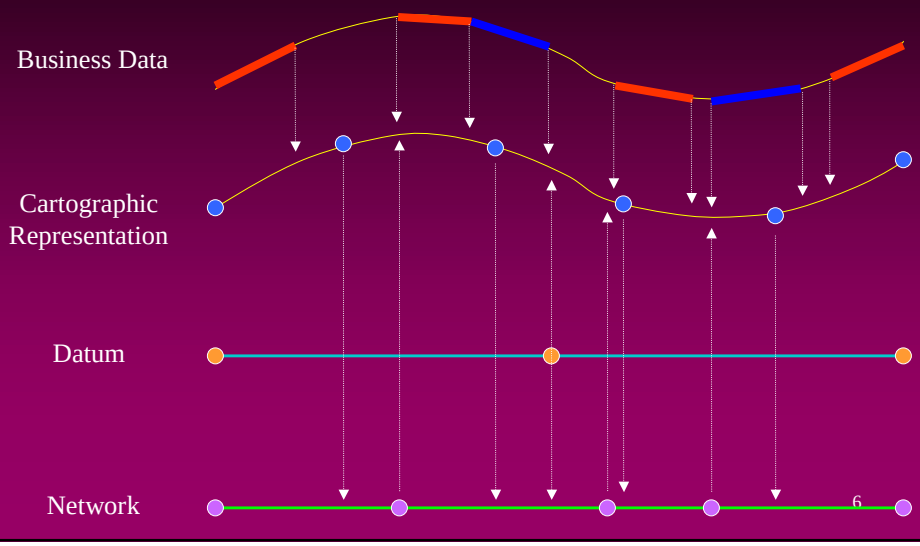
Linear Referencing

The problem we tried to solve...



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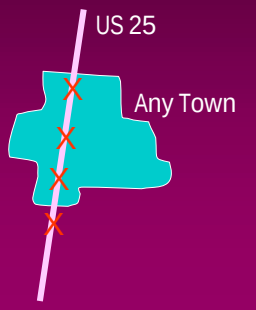
LRS Complexities

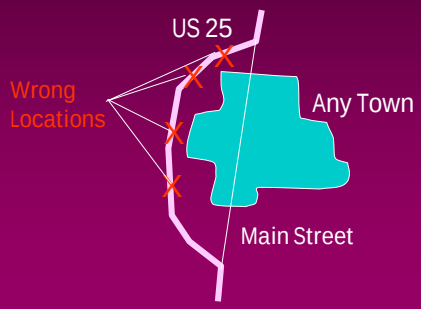
Route-based network links

By-pass example:

Before by-pass



After by-pass



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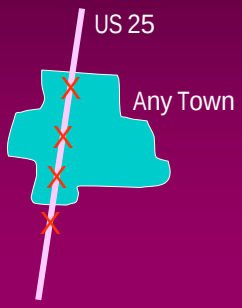
LRS Complexities

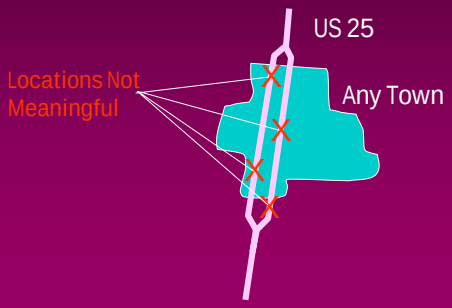
Route-based network links

Improved roadway example:

July 27, 1999



July 27, 2000



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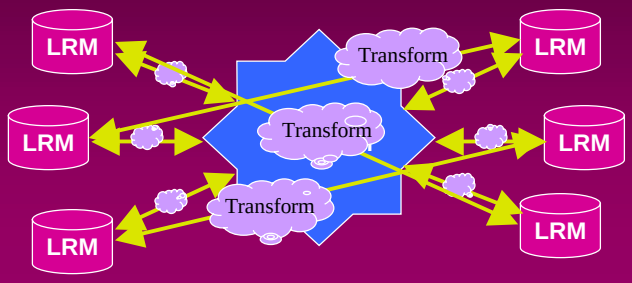
Linear Referencing

The problem we tried to solve...

A common linear description of the network that can relate all the methods.



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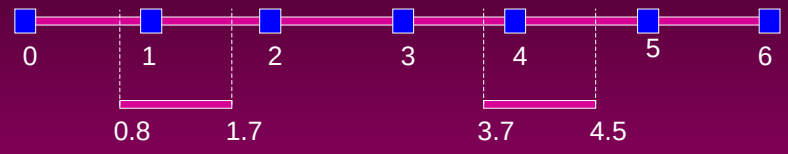
Linear Referencing Methods

Distance Measure

Route 0023



ROUTE_ID	BEGIN_DISTANCE	BEGIN_SECID	END_DISTANCE	END_SECID	ATTRIBUTES
0023	0.8		1.7		...
0023	3.7		4.5		...

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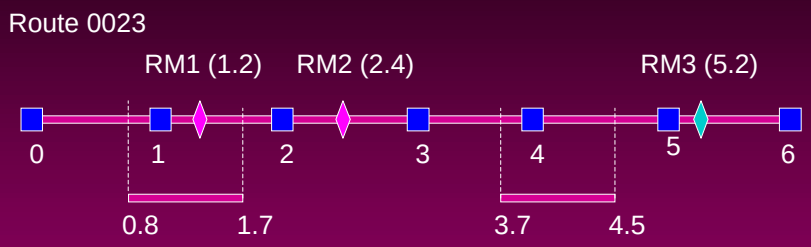
Linear Referencing Methods
Reference Marker Offsets



ROUTE_ID	BEGIN_MARKER	BEGIN_OFFSET	BEGIN_SECID	END MARKER	END_OFFSET	END_SECID	ATTRIBUTES
0023	RM1	-0.4		RM1	0.5		...
0023	RM2	1.3		RM3	-0.7		...

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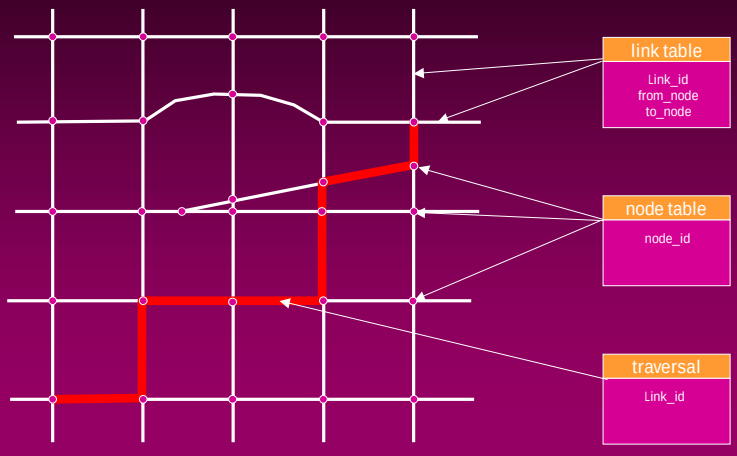
Network Modeling
Routes, traversals and path analysis



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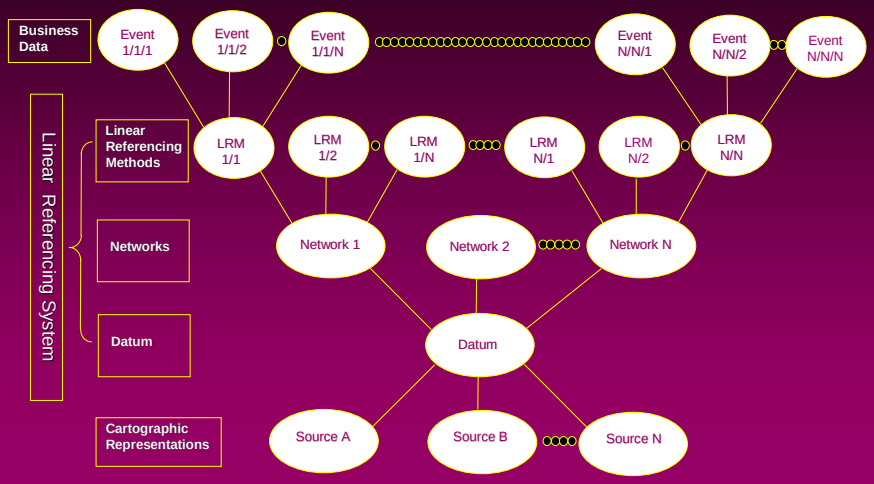
NCHRP 20-27 Conceptual Model



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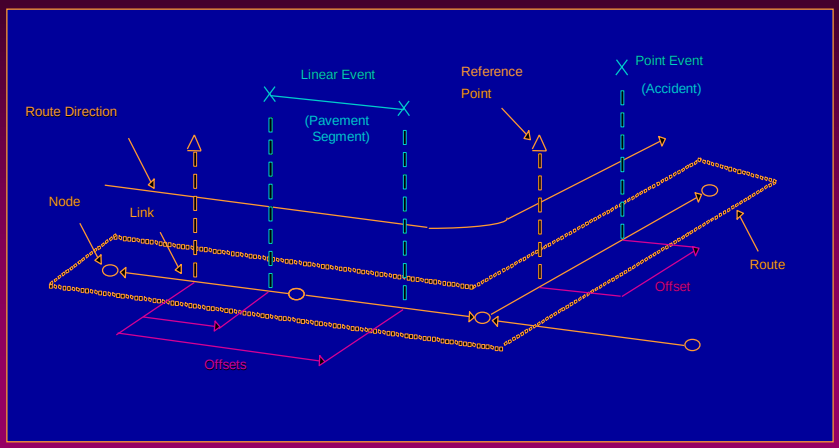
LRS Conceptual Data Model

Linear Referencing Method & Business Data



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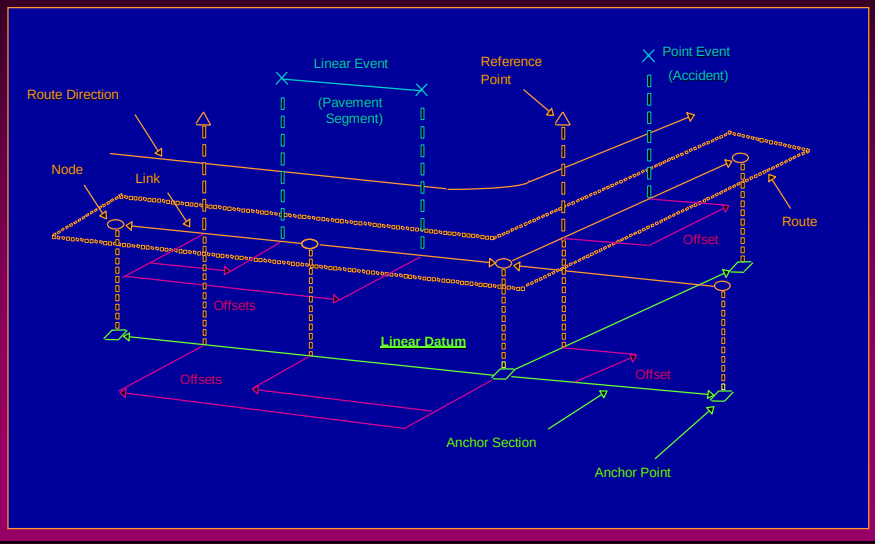
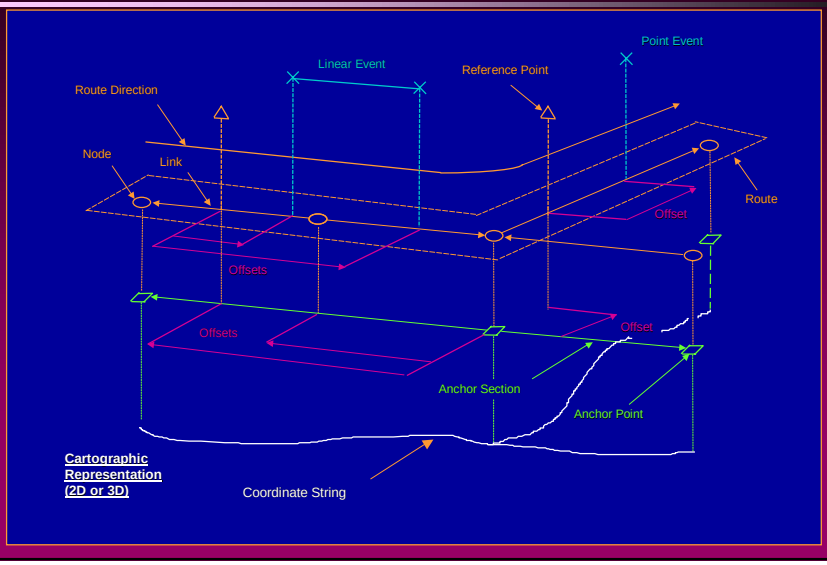
LRS Conceptual Data Model

LRM, Business Data, and Linear Datum

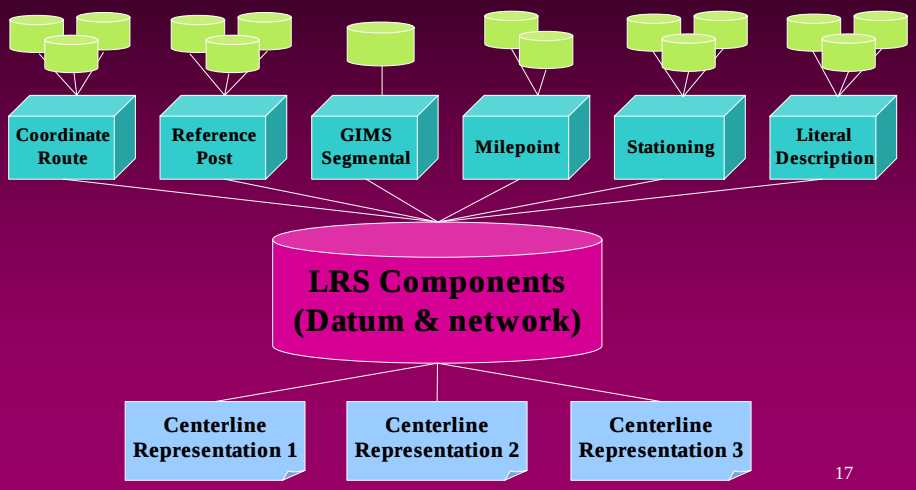


LRS Conceptual Data Model

LRM, Business Data, Linear Datum, & Cartographic Representation



LRS Operational Design
Conceptual Architectural Model



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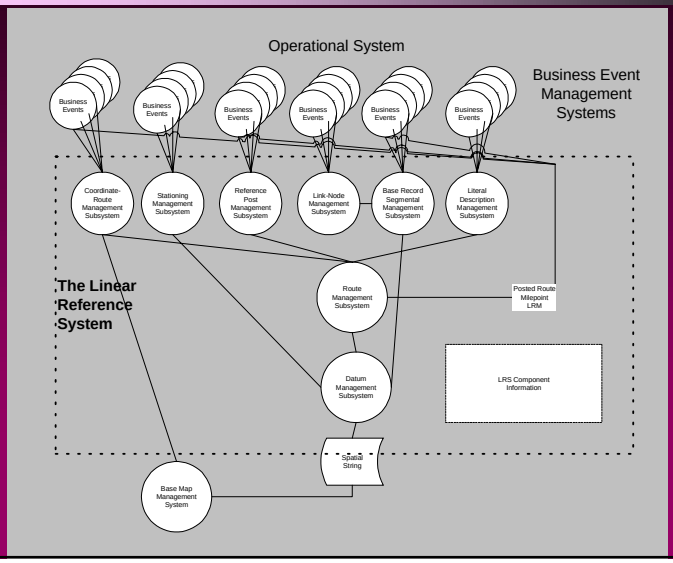
LRS Operational Design
Logical Architectural Model



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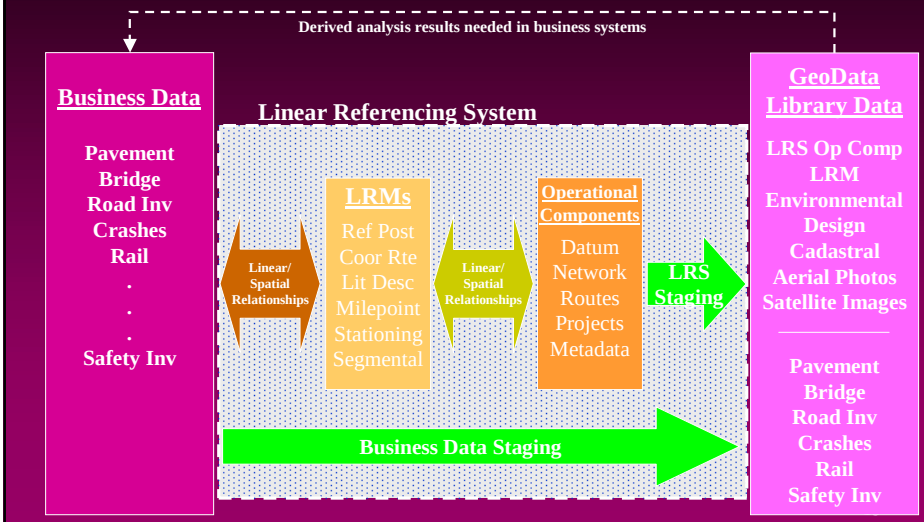
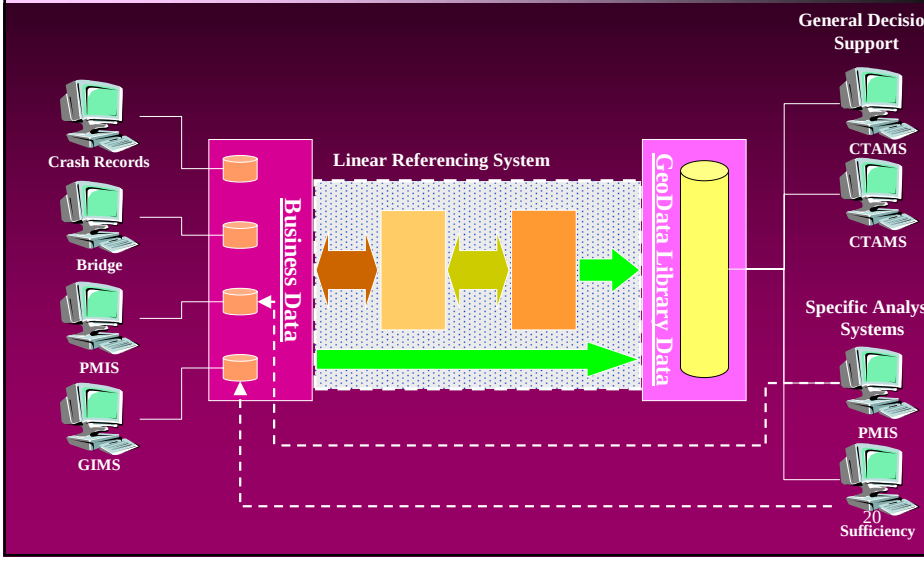
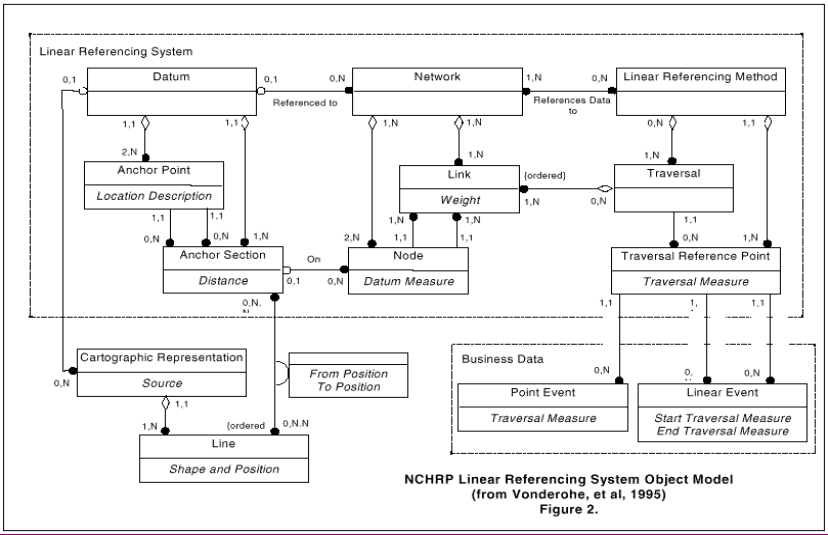
LRS Decision Support Design
Conceptual Architectural Model



LRS Decision Support Design
Conceptual Architectural Model



Linear Referencing Systems
NCHRP 20-27(2) - Object Model



NCHRP Linear Referencing System Object Model (from Vonderohe, et al, 1995) Figure 2.

LRS Project Approach
LRS Team Recommendations

- Improve accuracy of features referenced to road network
- Minimize redundancy in databases
- Minimize data maintenance
- Provide improved data integration & access
- Include all public roads

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LRS Project Approach
LRS Team Recommendations

- Establish a Linear Datum based upon the NCHRP 20-27(2) model
- Evaluate its effectiveness in a pilot study
- Move from a static base record to one that is updated in real time

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LRS Project Approach
Project Phases

- LRS Needs Assessment (August 99)
- LRS Design
- LRS Pilot Plan
- LRS Pilot
- LRS Design Revisions
- LRS Implementation Strategy & Benefits
- Project 2 Cost Estimate

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LRS Project Approach
Design Phase Subtasks

- Conceptual - To understand/obtain consensus on key system elements, resolve issues from assessment, and determine final scope
- Logical - To capture the business requirements; focusing on the what, but not the how
- Physical - To determine how to best implement requirements in the targeted technologies (GeoMedia, Oracle, etc)

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LRS Project Approach
Pilot Phase

- To test the design prior to implementing statewide. The pilot should focus on:
- Phase focus:
  - » Field data collection processes
  - » Key system elements construction
  - » Key system elements testing (benchmark results)

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LRS Project Approach
Redesign Phase

- To determine the solutions to key issues or problems with the LRS design discovered during the pilot
- Phase focus:
  - » Key system issues inventoried
  - » Best alternatives determined
  - » Impacts to design and implementation assessed

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Datum Field Measurement Decisions

Bill Schuman and Steve Kadolph

Iowa DOT

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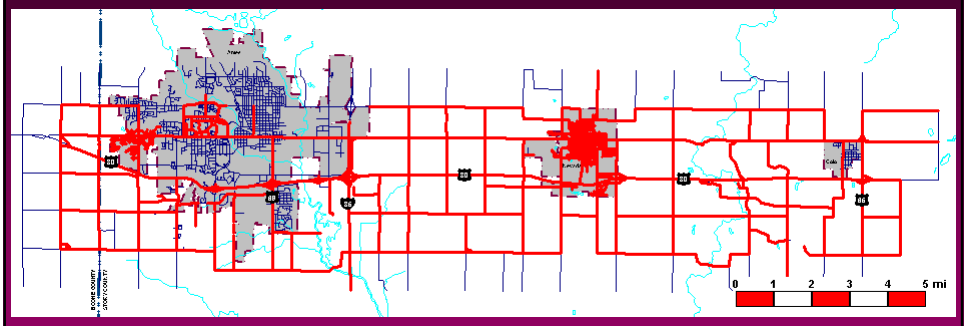
LRS Pilot Area

Story and Boone County



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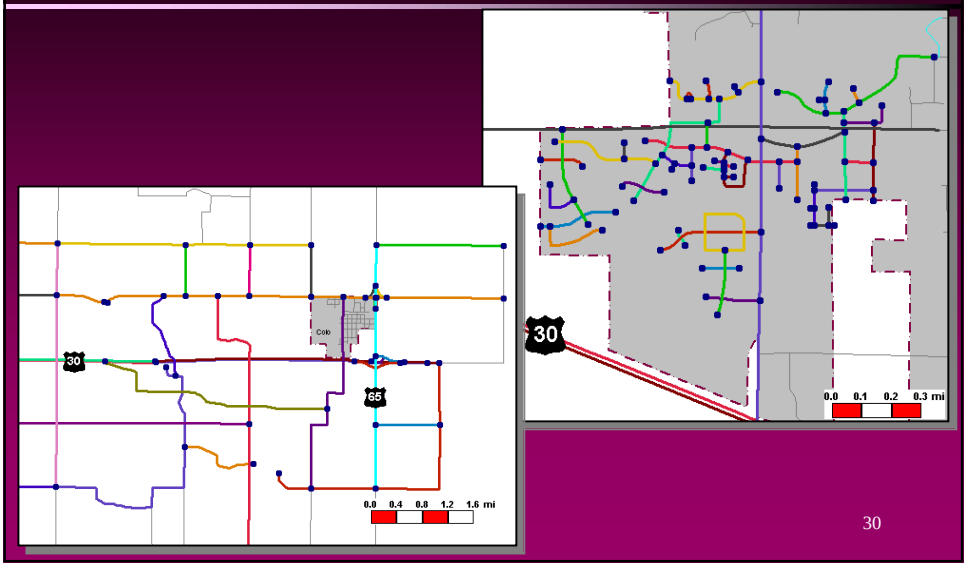
Anchor Point and Anchor Section Configuration



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Datum Measurement Methods

Anchor Point	Anchor Section
RTK GPS	DMI video van
Differential GPS	GPS video van
Aerial ortho photos	Aerial ortho photos
Project plans	Project plans
	Cartography
	Inventory data

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Anchor Points - Accuracy

- Absolute accuracy - the allowable error in longitude, latitude, and elevation on the reference ellipsoid.
- Absolute accuracy of known points, specifically anchor points, must be one meter or less.

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Anchor Point
Measurement Options

- Data collected in the field for Pilot
  - » Real time kinematic GPS
  - » Differentially corrected GPS
- Other methods used
  - » Story county aerial orthos
  - » Nevada subdivision plats
  - » Primary project plans

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Points Measured in the Field
Real Time Kinematic

- Anchor Points (103)
- Mile Posts (35)
- Bridges (10)
- Stations (32 - 16 each direction)

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Anchor Point Types

- Intersections
- Bridges/Railroads
- Dead ends
- Cul de sac
- Ramps
  - » Gore points
  - » Taper points

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Anchor Section - Accuracy

- Relative accuracy - allowable error in linear distance measurements between an anchor point and a reference point on the same anchor section
- Relative accuracy of 10 meters or less should be achieved.

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Anchor Section
Measurement Options

- Data collected in the field for Pilot
  - » Distance measuring device
  - » Differentially corrected GPS
- Other methods used
  - » Story county aerial orthophotos
  - » Primary project plans
  - » Cartography
  - » Inventory data

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Objects Measured in the Field
Video Log (GPS & DM)

- Anchor Sections (252)
- Spans (8)
- Stations (32)
- Mile Posts (35)
- Bridges (9)

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Observations
Field Measurement Problems

- Dead ends are sometime inaccessible
- Frequently it is impossible to stop
- Milepost data gathering time consuming
- Good cartographic products are necessary
- Ramps require field scouting

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Accuracy vs. Cost

- Compare methods
- Look at scope
- Choose one or more methods to implement

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Measurement Selection

- Accuracy was the driving factor
  - » Hypothesis formulated
  - » Data gathered
  - » Statistical tests performed
- Cost and its impact on accuracy
- Choose methods to implement

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Datum Creation

Methods Selected

- No one method met all requirements
- Redundant measurements required
- Orthophotos (AS & AP)
  - » Use best orthophotos available
  - » USGS DOQQs (accuracy relaxed)
- DMI/DGPS (AS)
  - » Required for ramps
  - » Missing data

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Datum Maintenance

Methods Selected

- Primary System
  - » Design Plans
  - » DMI/DGPS
- City and County Roads
  - » Plans - Work with local agencies
  - » DMI/DGPS - Inventory process

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Future

Measurement Options

- Real Time Kinematic
  - » Anchor Points
  - » Reference posts
  - » Reference features (bridges xings)
- Municipal and County Roads
  - » Focus on Arterials and collectors
  - » Reduced accuracy on local roads
  - » Work with local governments

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Organizational Decisions

- Collection to be done external
  - » Fill a LRS Manager position
  - » Staff involved in collection process
- Maintenance to be done internal
  - » Temporary increase in staff
  - » Better equipment
    - –DMI and DGPS
    - –Software needed for data collection

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Tools Required

- Visualization tools
  - » Required to create/modify datum objects
  - » Ensure process is complete
- Software to perform adjustment process
  - » Average measurements for accuracy
  - » Quality control
- Mission planning tools
  - » Required for efficient operation

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Database Model

Tom Ries
GeoAnalytics, Inc.

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Key Database Requirements

- Datum/Carto/Network
- Routes for Linear Reference Systems
- Temporal Handling
- Multiple Linear Reference Methods

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Datum / Carto / Network
Requirements

- Keep Datum/Carto/Network distinct
- Datum: most stable rep of roadway
- Datum: quantify accuracy
- Carto: support spatial analysis (GIS)
- Network: LRM foundation
- Network: routing fundamentals

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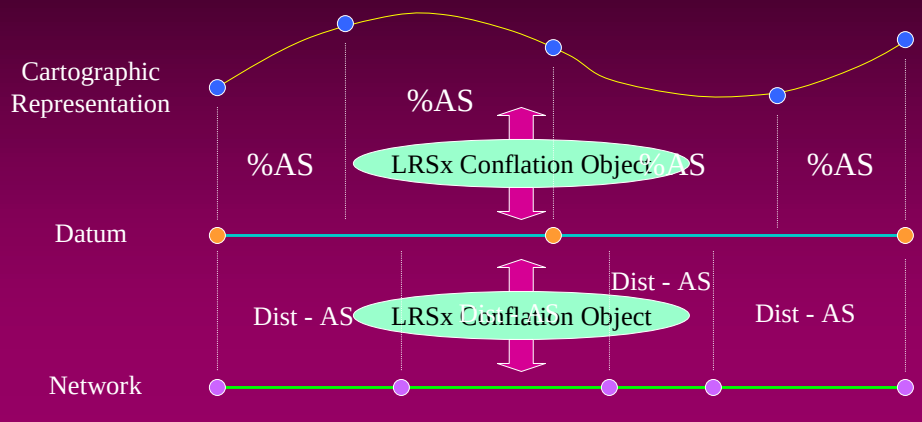
Datum / Carto / Network
Feature Association



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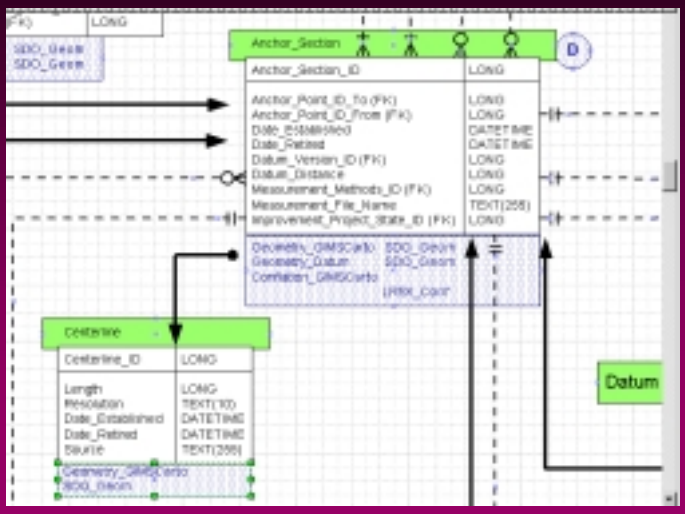
Datum / Carto / Network

Datum and Carto Association



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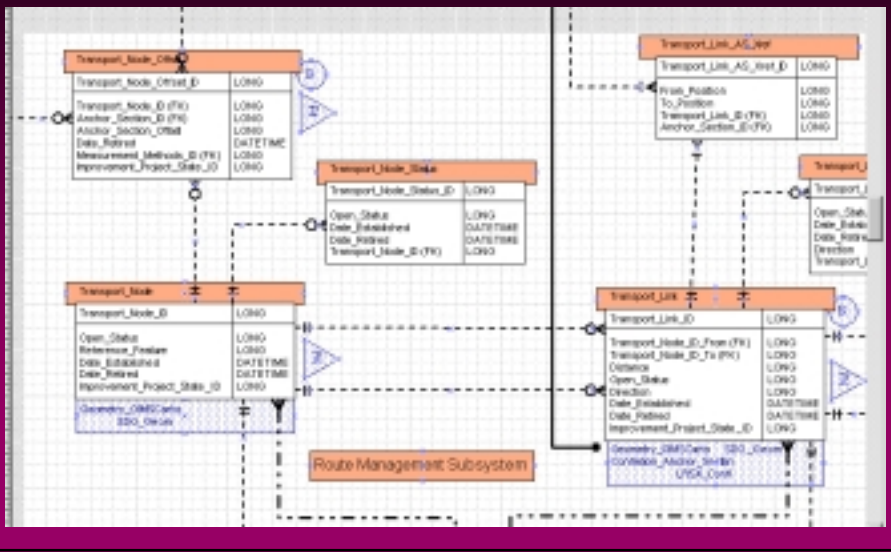
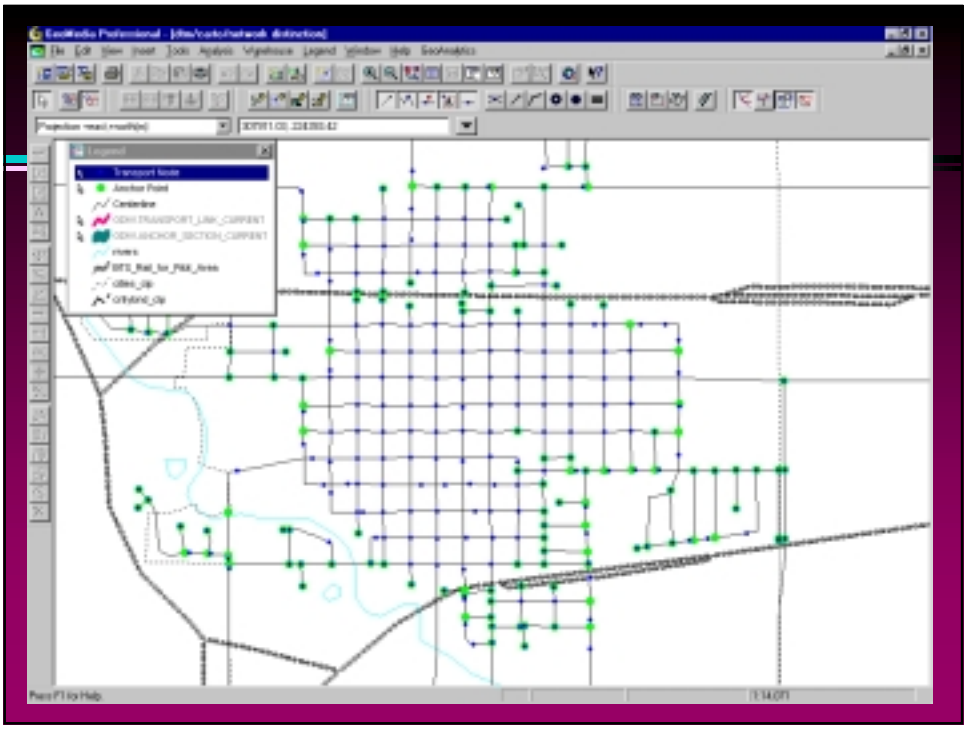
Datum / Carto / Network

Datum and Network Association





Datum / Carto / Network

- Linear/Linear Registration and Calibration Approach
- Conflation Management
  - » GIS Editing Tools for Real World Distance Editing
  - » Node Handling Part of Edit/Dyn Seg Process
- Networking Applications
  - » Network Data Independent of Geometry Condition

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Key Database Requirements

- Datum/Carto/Network
- Routes for Linear Reference Systems
- Temporal Handling
- Multiple Linear Reference Methods

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Route Requirements

- All Posted Route Systems
- Unique Route Names
- *Ramp Naming*
- *Route Aliases*
- *Concurrency Handling*
- *Detour Handling*

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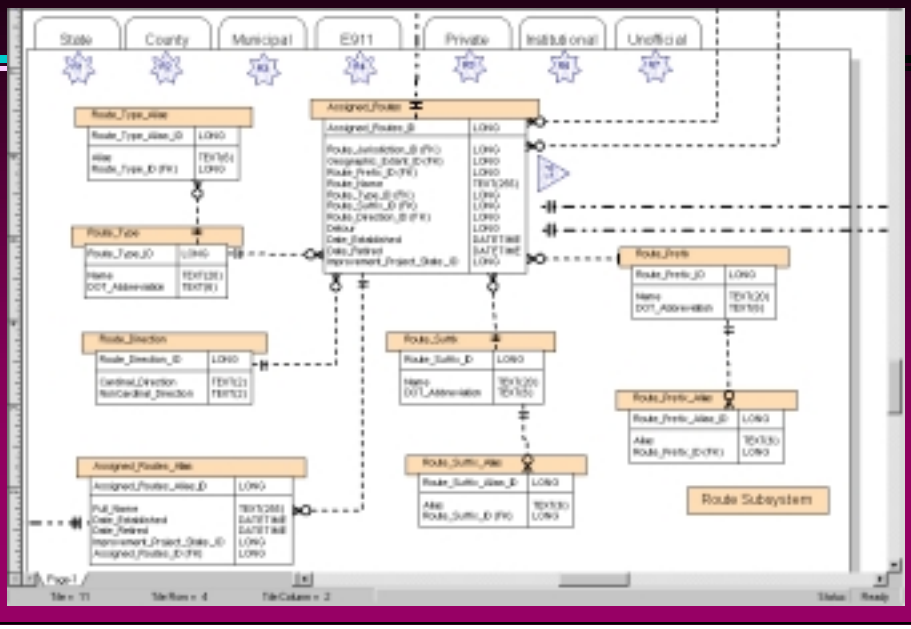
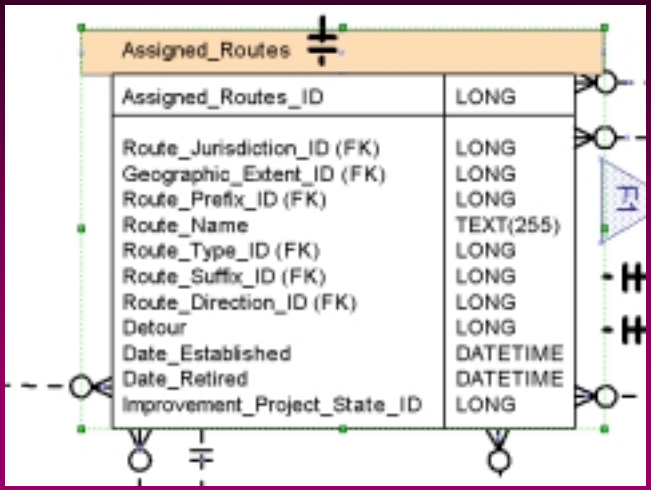
Route Requirements - *Route Systems*



Route Requirements

Unique Route Names - Decomposition



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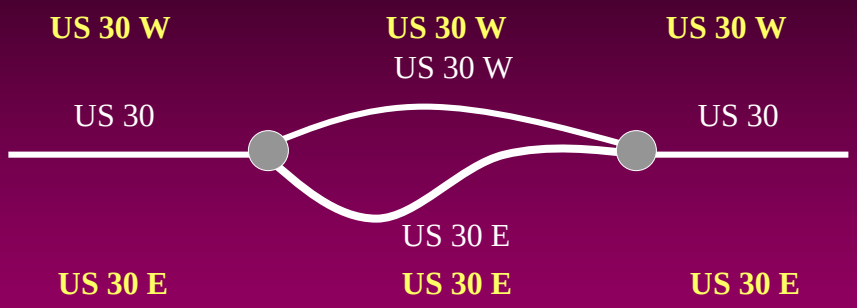
Route Requirements

Unique Route Names – Opposite Directions



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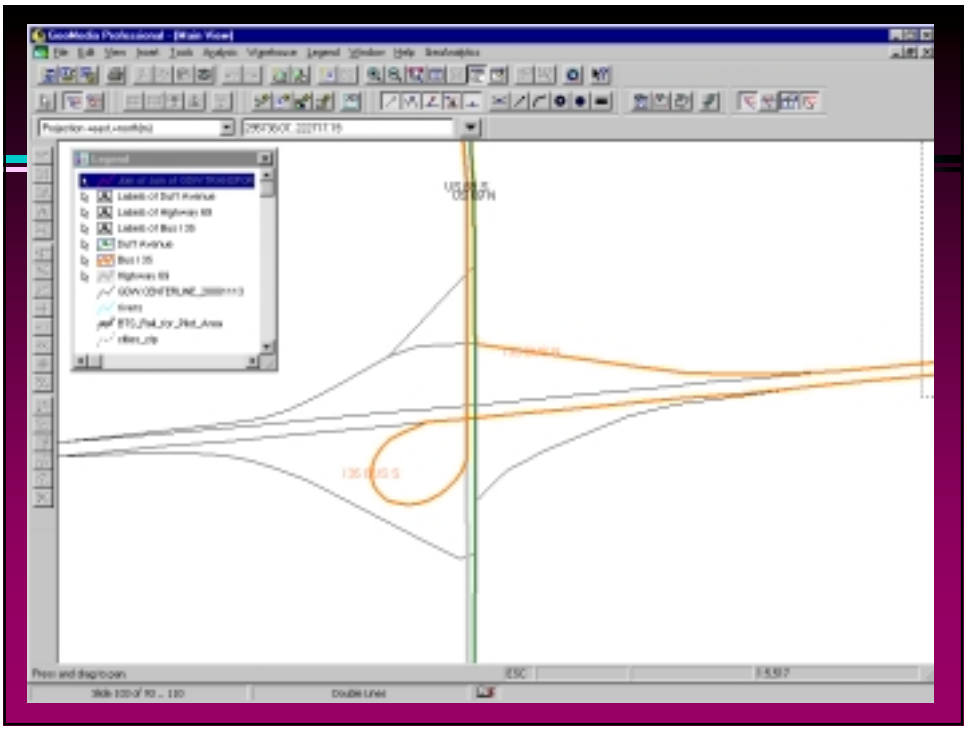
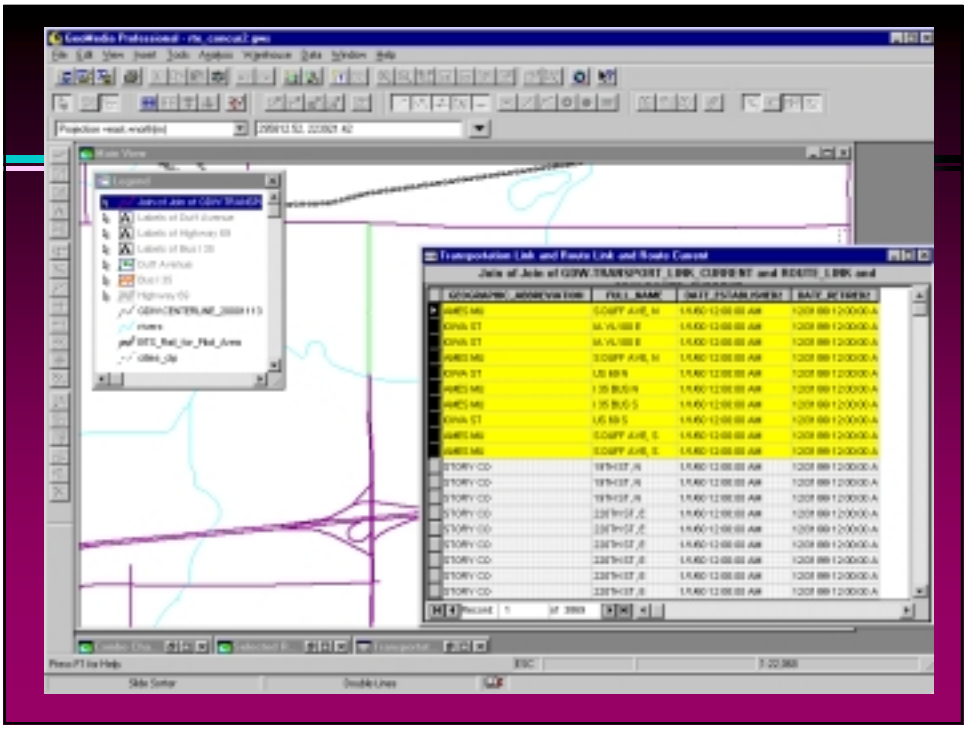
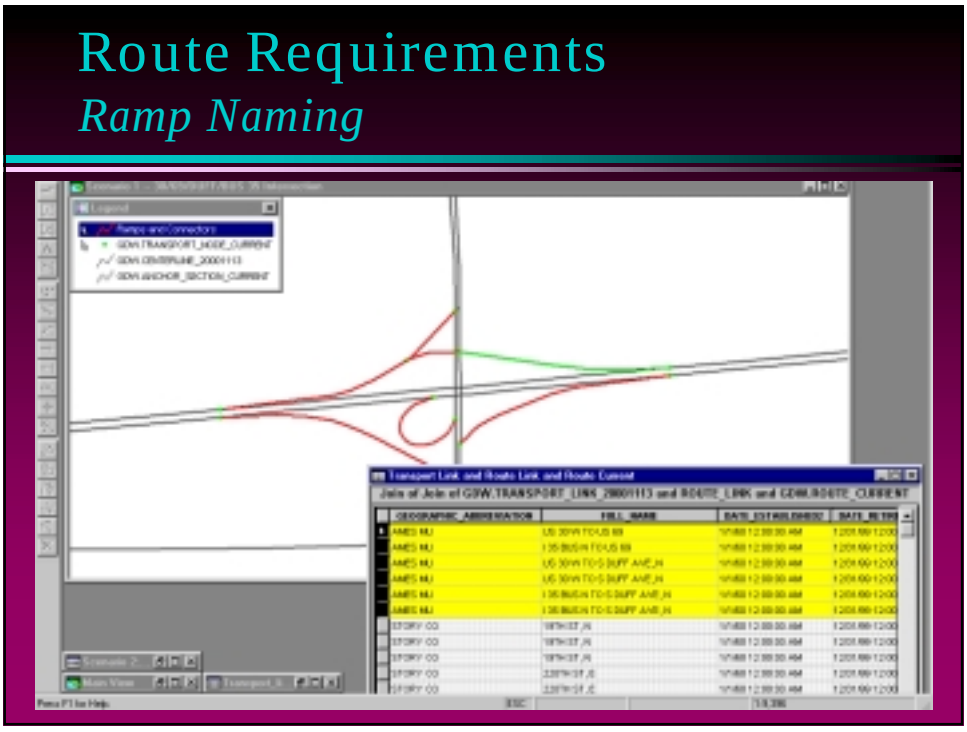


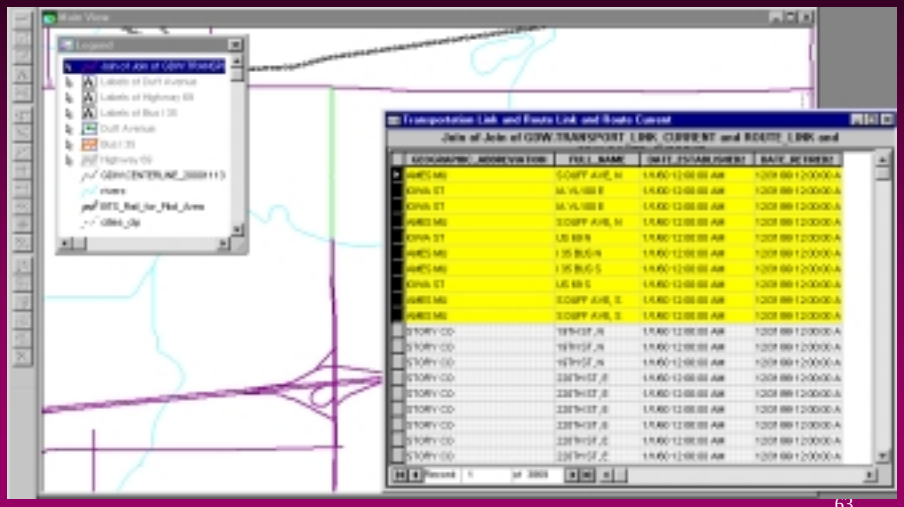


Route Requirements

Ramp Naming



Route Requirements
Concurrencies



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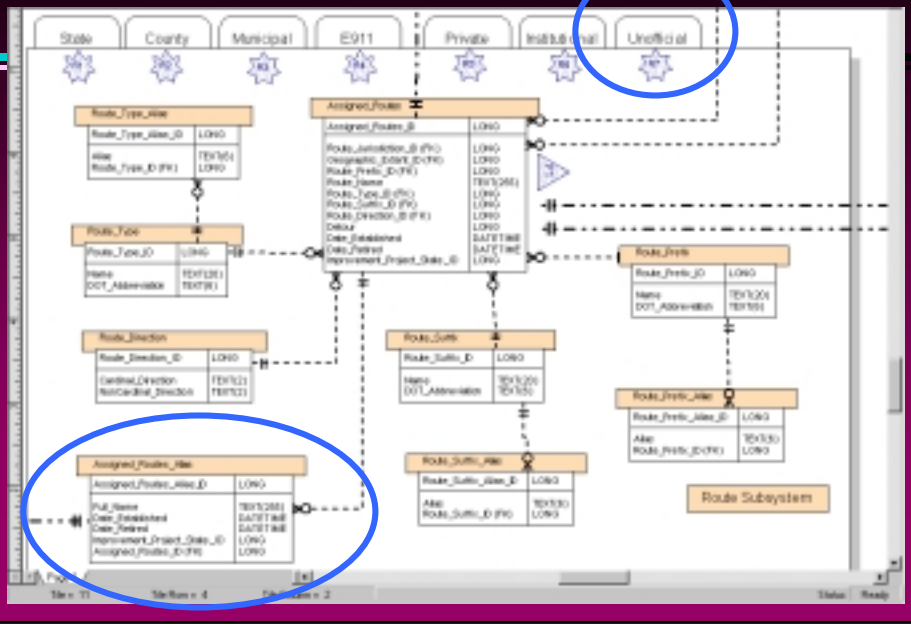
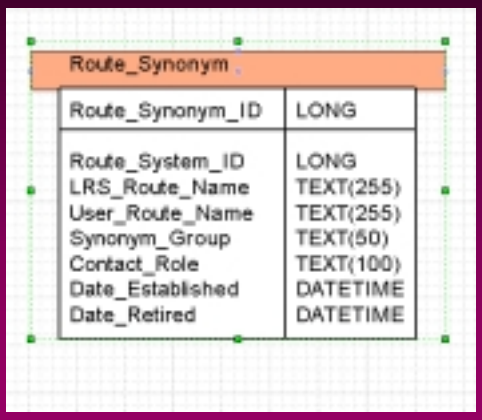
Route Requirements - *Route Aliases*



Route Requirements

Concurrencies > Route Alias Synonym



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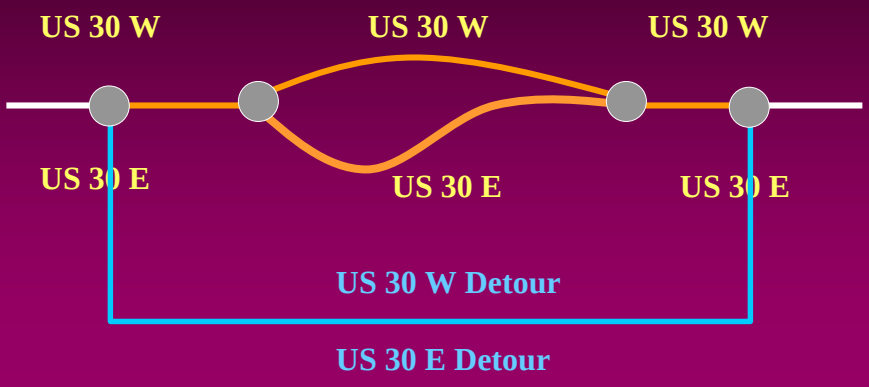
Route Requirements

Detours



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Key Database Requirements

- Datum/Carto/Network
- Routes for Linear Reference Systems
- Temporal Handling
- Multiple Linear Reference Methods

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Temporal Requirements

- Historic and Proposed Representation
- *Event tracking*
- *Feature tracking*

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Temporal Requirements
Historic and Proposed Representations

- Real World Dates
  - » *Date Established, Date Retired*
- Database Dates
  - » *Date Established, Date Retired*
- States
  - » *Strategic, Planning, Design, As-built*
- State Categories (Derived)
  - » *Proposed, Current, Retired*

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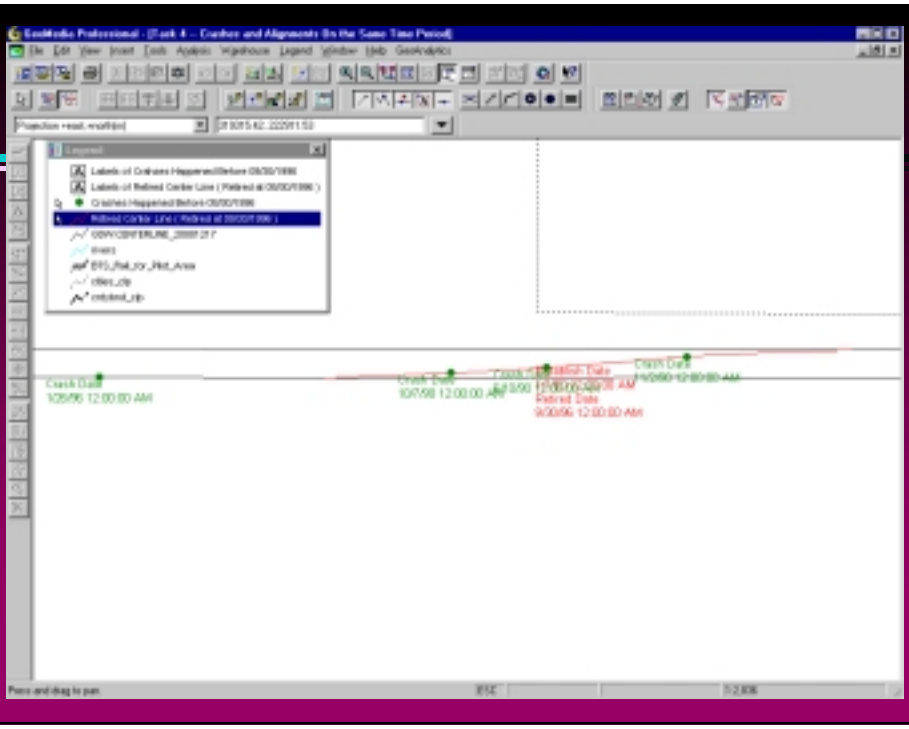

Temporal Requirements
Event Tracking

- Real World Changes
  - » Alignment, Non-alignment (routes)
- Database Changes
  - » Extension (out of state), Enhancement (improved measurement), Error (wrong measurement)
- Reason Detail
  - » Project, Feature Category, and Specific Feature Levels

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Temporal Requirements
Feature Tracking

- Specific Linear Location
  - » Anchor Section Associations
- Other Feature Associations
  - » Improvement Project Level
  - » Feature Level

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Key Database Requirements

- Datum/Carto/Network
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Location Reference Methods
Initial Official DOT "Linear" LRMs

- Reference Post (was called milepost)
- Literal Description
  - » Cross-street (derived)
  - » Reference Feature (bridge, rail crossing)
- Coordinate Route (process)
  - » Primary Format: Route, X*begin*, Y*begin*, X*end*, Y*end*
- Segmental (control section)
- Milepoint (accumulative, derived)
- Stationing (improvement project plans)

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Location Reference Methods
Literal Description (LD) Output

Comments	*LD Output Results*
Only one of several required OUTPUT formats for LD	LD{ON {10TH ST, N} AT {C AVE, W} TOWARD {D AVE, W}, 0.000 FOR 167.258}
Offset value - fuzzy tolerance needs	LD{ON {15TH ST, N} AT {IA VL100 E} TOWARD {M AVE, E}, 1.156 FOR 115.208}
On/at at same route	LD{ON {16TH ST, N} AT {16TH ST, S} TOWARD {H AVE, E}, 0.000 FOR 284.178}
Ramp names included	LD{ON {19TH ST, N} AT {19TH ST, N TO US 30 W} TOWARD {W 4TH ST, S}, 27.958 FOR 374.286}
Use of non-posted routes	LD{ON {IA VL100 E} AT {I 35 BUS N} TOWARD {I 35 BUS N}, 334.936 FOR 334.936}
Different business data with same on/at/towards	LD{ON {IA VL100 E} AT {I 35 BUS N} TOWARD {US 69 S}, 15.053 FOR 30.126}
	LD{ON {IA VL100 E} AT {I 35 BUS N} TOWARD {US 69 S}, 165.477 FOR 100.282}

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Other LRS Database Features

- Network Status
- Nested Networks
- Ramp Decomposition
- Datum Real World Locations
- Transport Systems

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Physical Technical Environment

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TransDecision, Inc.

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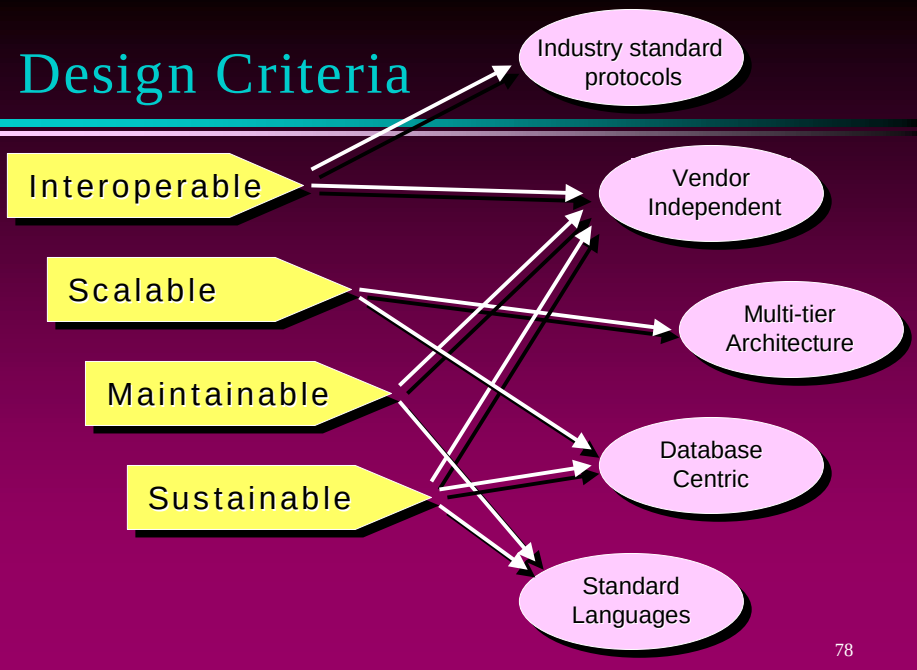
Design Criteria



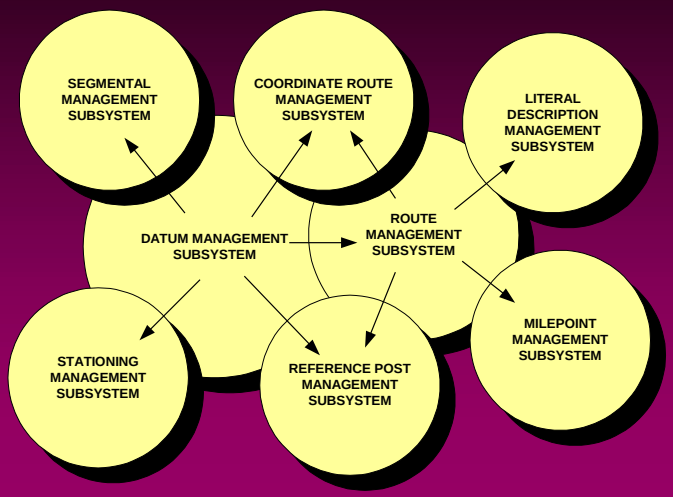
78

Design Issues

- Institutional
  - » Compatibility with GeoMedia Clients
  - » DOT's Information Systems strategy
- Engineering
  - » Legacy clients
  - » Structured Data
  - » Web-Enabling

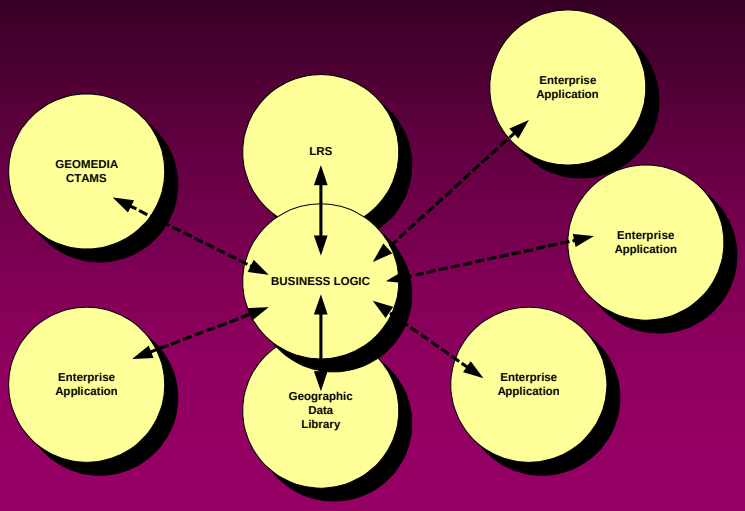
79

Subsystem Interoperability



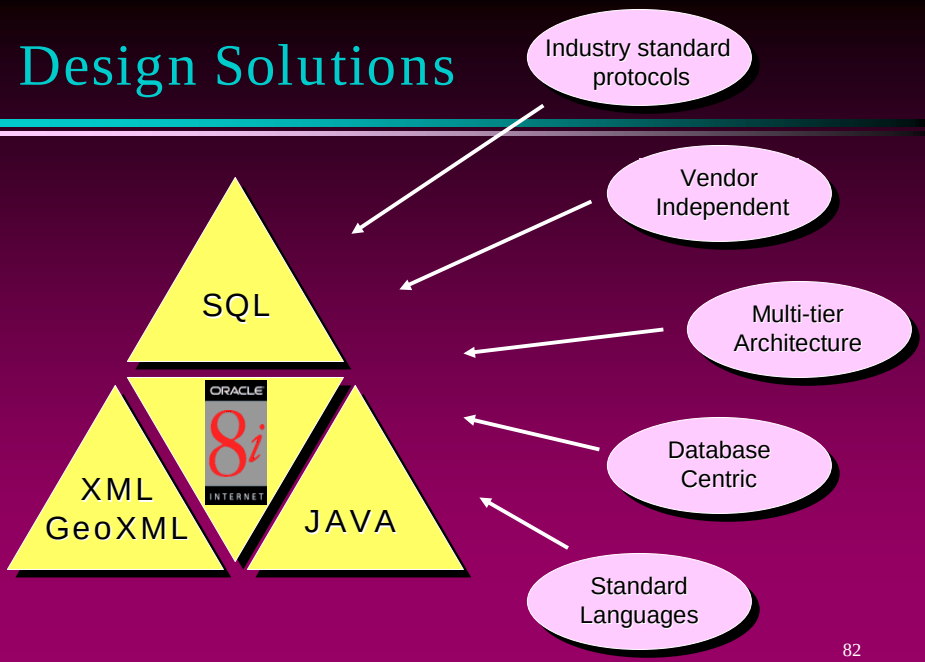
80

Application Interoperability



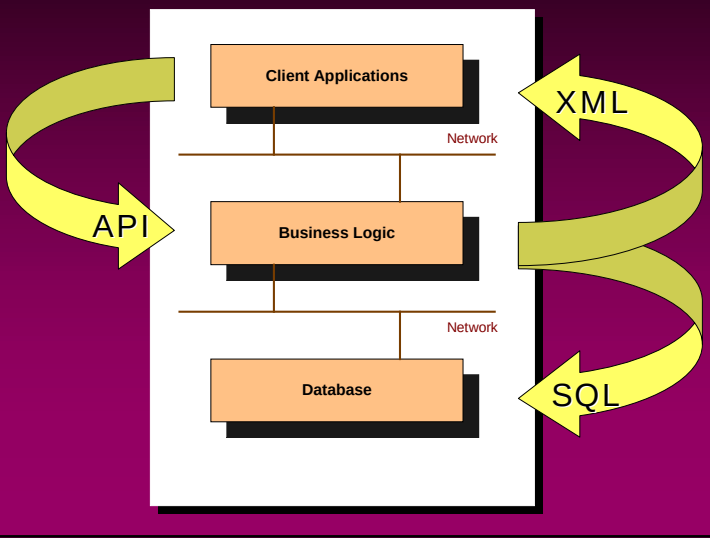
81

Design Solutions



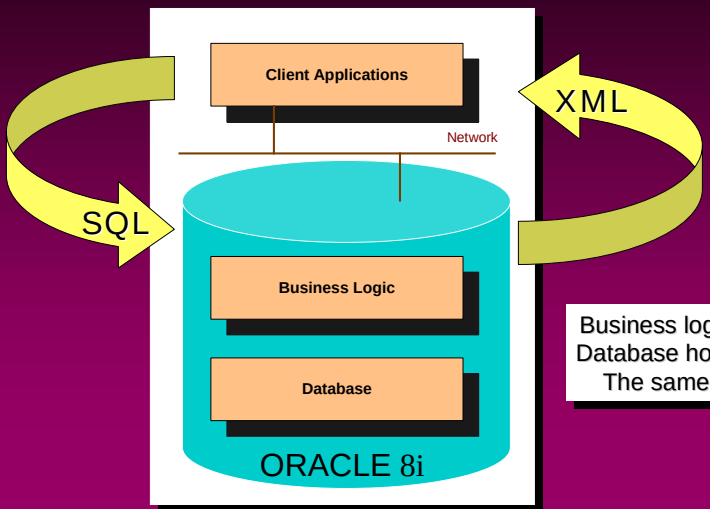
82

Conceptual Architecture



83

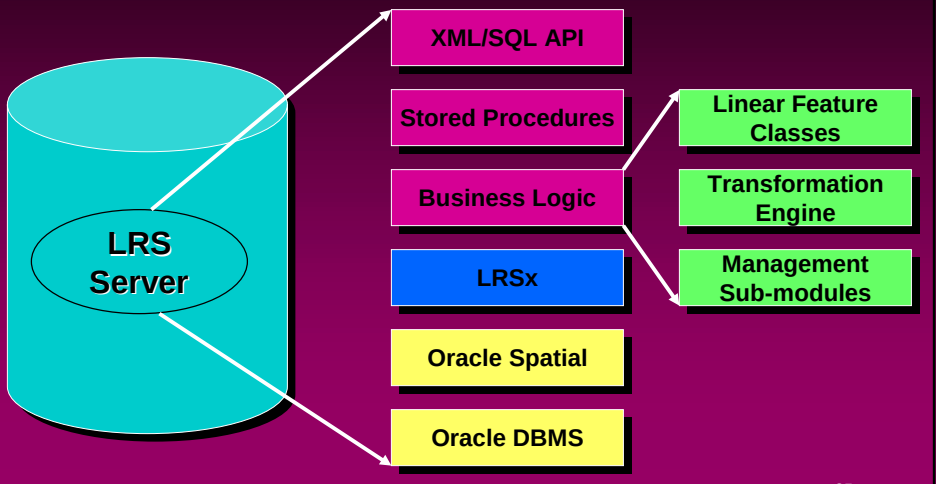
Implementation Architecture



Business logic and Database hosted in The same tier.

84

Opening the Box



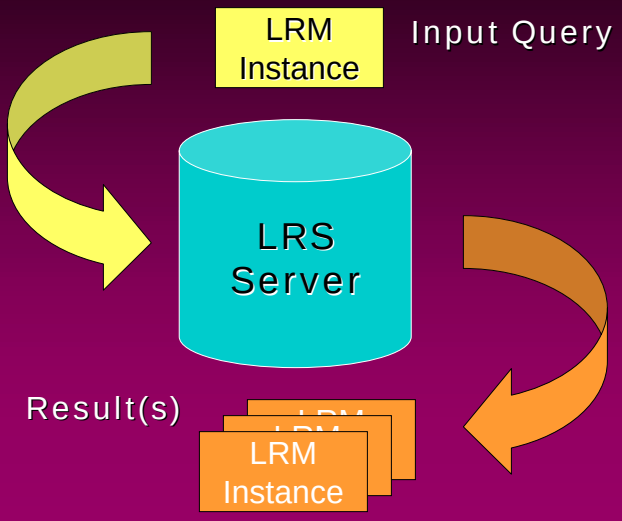
85

Issues to Overcome

- Managing Structured Data
  - » How LRM instance information will be passed between client and server
- Managing Structured Requests
  - » How LRS clients will request transform or overlay operations and present LRM instances

86

Managing Structured Data

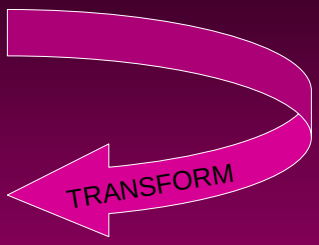


87

Structured Data Example

RP Route XYZ, From Post 123 + 0.25mi, To Post 125 – 0.50mi, 4/10/2001

AS 1234, FROM 500.00m TO 1250.00m
AS 5678, FROM 0.00m TO 650.00m
AS 9101, FROM 3456.00m TO 3245m



Issues for Storage, API Parameters, Interoperability

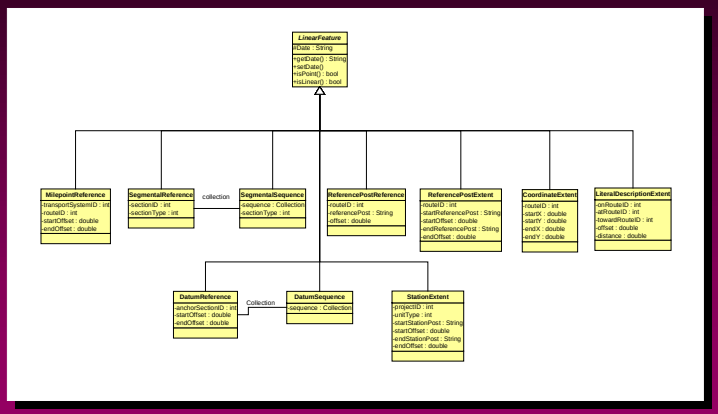
88

Location Reference Instance Types

- LRM Types
  - » Milepoint, Reference Post, Datum, Stationing, Segmental, Coordinate Route, Literal Description, Geometry
- Extent Types
  - » Point and Linear
- Collections
  - » Unordered and Sequenced

89

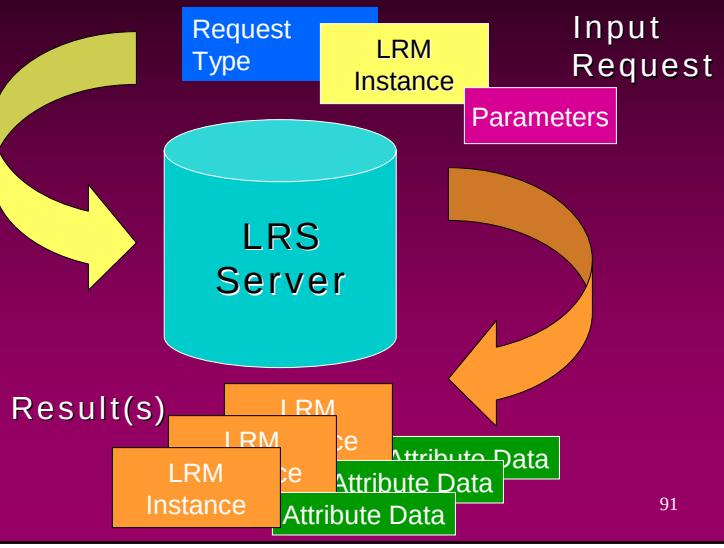
Linear Feature Class Design



XML DTD reflects Linear Feature class model

90

Managing Structured Requests



91

XML Document Type Definitions

- Three XML DTDs Developed
  - » Linear Feature DTD
  - » Linear Overlay Request DTD
  - » Linear Transform Request DTD
- Uses GeoXML DTD for Geometry

Interoperable clients need only to be able to process XML which conforms to the LRS DTDs to be able to perform linear transform and overlay operations.

92

Future of Iowa DOT LRS

Bill Schuman

Iowa DOT

93

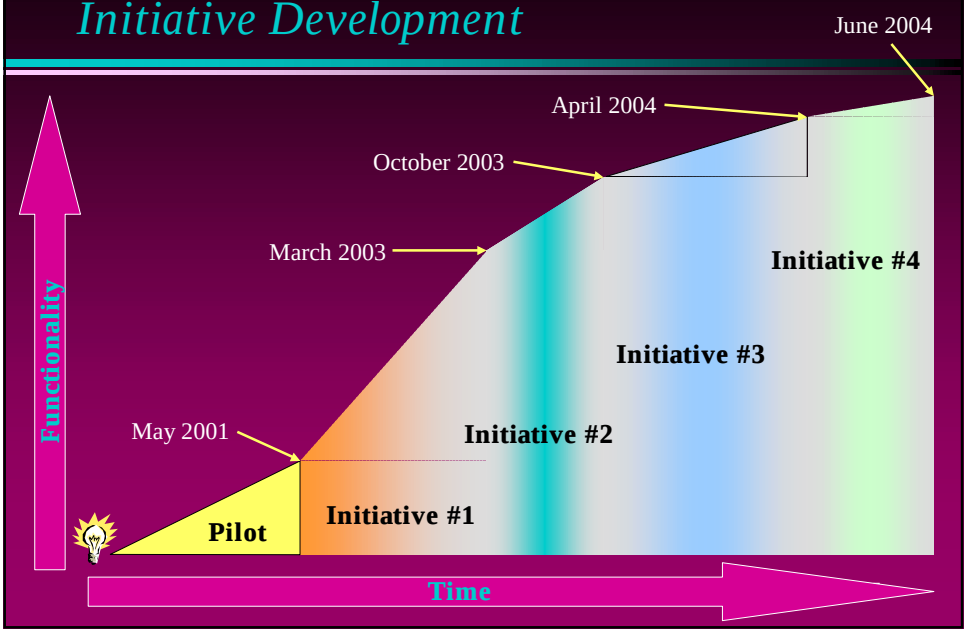
LRS Pilot Project Findings

- Found a practical approach to applying the NCHRP 20-27 LRS model
  - » Temporality
  - » Datum-based LRMs
- Our list of LRMs can be integrated using the 20-27 model
- Desired accuracies are achievable
- Most important – IT WILL WORK!

94

LRS Development Strategy

Initiative Development



Future LRS Development

Planned Development

- Initiative #1
  - » Finalize LRS data model
  - » Develop LRS maintenance application
  - » Design LRS datum and capture datum measurements for primary road system
  - » Deploy reference post, segmental, & coordinate/route LRMs
  - » Develop first user applications
  - » Coordinate change management

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Future LRS Development
Planned Development

- Initiative #2
  - » Enhance and finalize maintenance application
  - » Collect local roads in a region
  - » Develop milepoint and literal description LRMs
  - » Develop second level user applications
  - » Coordinate change management

97

Future LRS Development
Planned Development

- Initiative #3
  - » Collect all remaining local roads
  - » Design/develop other LRMs (address ranges?)
  - » Support user application development
  - » Coordinate change management

98

Future LRS Development
Planned Development

- Initiative #4
  - » Develop stationing LRM
  - » Support user application development
  - » Coordinate change management

99

Questions

100

GIS-T Symposium
Tennessee DOT
TRIMS

Pat Broussard

April 7, 2001

Information Management System

Enterprise transportation management system

- Began development in 1995
- 700 users across TDOT
- Brings all types of information to the enterprise

Phased Approach

- Roadway Inventory Database
- Reporting
- GIS
- Web

INTERGRAPH
GOVERNMENT SOLUTIONS

Benefits and Methodology

Benefits of Phased Approach
- More easily managed
- Reduces risk
- Quicker ROI

Project Management
- Methodology
- Communication

INTERGRAPH
GOVERNMENT SOLUTIONS

References and Contacts

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TDOT Project Manager
(615) 741-3429

Pat Broussard
Intergraph Project Manager
(256) 730-8242


INTERGRAPH
GOVERNMENT SOLUTIONS
TRIMS Demonstration

GIS-T 2001

How Bi-Annual Terrestrial Stereo Digital Imaging Data was used for Asset Inventories and Litigation Mitigation at Maricopa County, Arizona

Presented by

David W. Baraniak, PE

Lambda Tech International, Inc.

Waukesha, Wisconsin

262-798-5262

www.lambdatech.com

Ben McCawley

Maricopa County, Arizona

602-506-4629

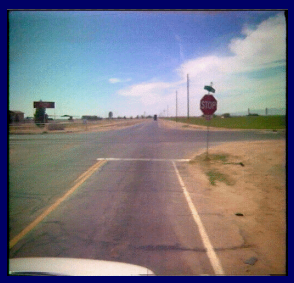
benmccawley@mail.maricopa.gov

GPSVision™

Virginia DOT Roads

GPSVision High Rail System

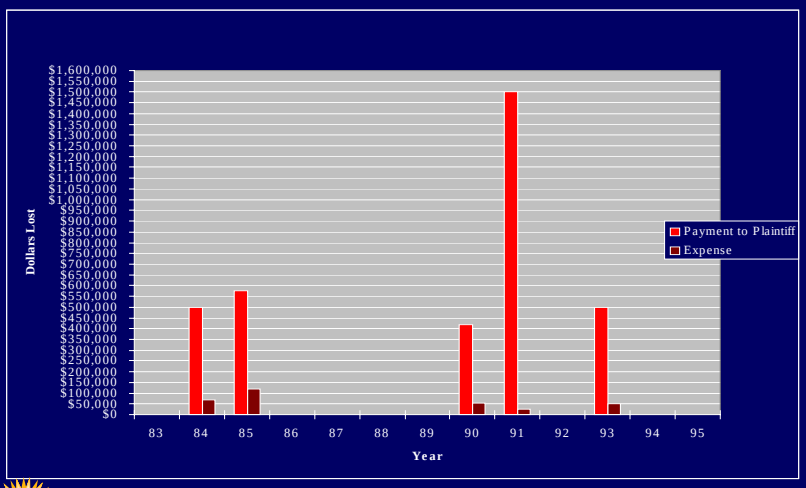
Road Imaging
or
Virtual Survey



History

- Lawsuit
- Inventory

Liability Expenditures on Missing or Damaged Signs



Before and After Pictures.

- Road Imaging
- Accident Imaging

Road Imaging

Accident Imaging

Feature Positioning

View Only Software

Traffic Engineering Division Accident Report 1997-2000

- **Since the beginning of the imaging program in 1996, Maricopa County has had no major liability litigation related to ROW signage and striping**
- **Saved county police, lawyer and engineering time**
- **Estimated savings of $3.2 million annually**

Additional Benefits

- **Improved sign and street data base**
- **Accurately counted 42,532 signs as of January 2001**
- **Links image to county data base**
- **Created as-builts of roadway**
- **Rubber sheeting raster images & vector maps using GPSVision control points**
- **GPSVision saved field survey time on existing roadways**

GPSVision Projects of Note

- Maricopa County DOT
  - GPSVision
- Level 3 / Metra
  - ROW Mapping/GPSVision
- Rhode Island DOT
  - GPSVision / road Geometrics
- Clark County / Las Vegas
  - Mapping and GPSVision
- Virginia DOT
  - Centerline Mapping/GPSVision

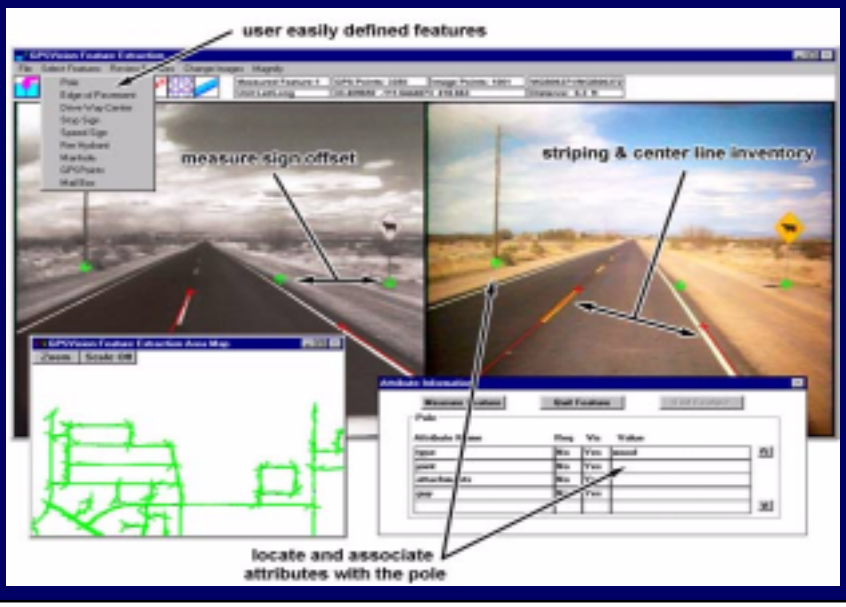
Typical Applications

- ROW Imaging
- Infrastructure Inventory
- Center lines for GIS
- Sign & Signal Inventory
- Bridge Locations
- Intersection Location
- Air Photo Rectification
- Lane Striping
- Utility Pole Mapping
- Tort liability
- Work Orders
- Incident Mapping

GPSVision™

- The mobile mapping system collects positionally accurate submeter stereo digital imagery that supports multiple GIS and CAD applications

Feature Extraction Screen



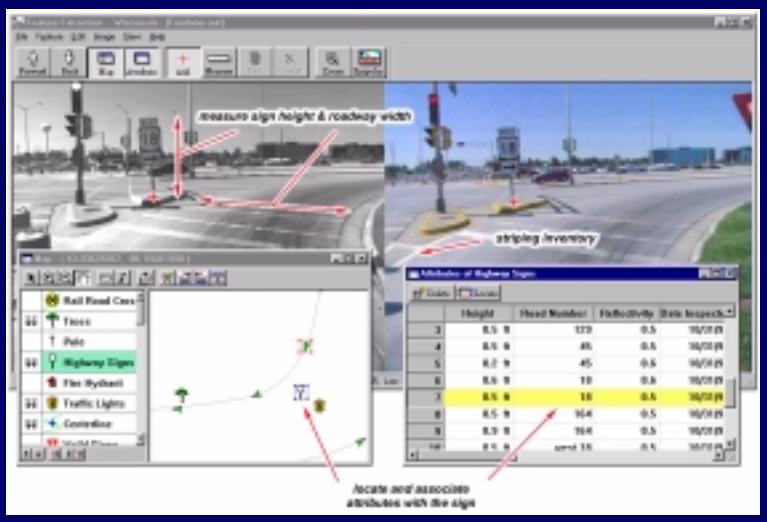
GPSVision™ System

- GPSVision designed in house at Lambda Tech includes:
  - System Hardware and Software
  - GPS Post-processing Software
  - GPS/INS integration Software
  - SVS Feature extraction Software
  - GIS Reformatting Software
  - View Only Software

GPS / INS / DMI

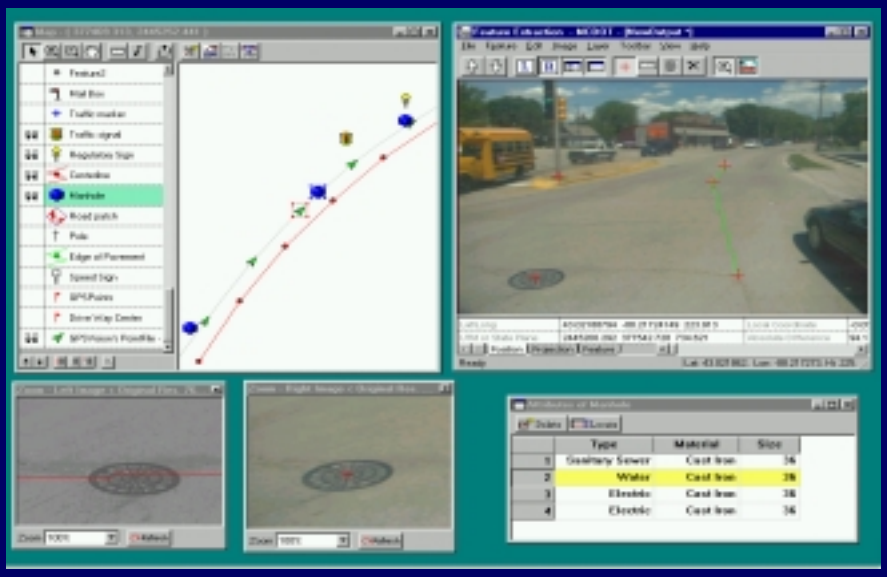
- Positioning Sensors
  - Dual Frequency GPS Trimble receivers
  - Solid state IMU Litton LN-200
  - Self Calibrating Distance Measuring Instrument
- Capable of maintaining location accuracy with no GPS for up to 10 minutes

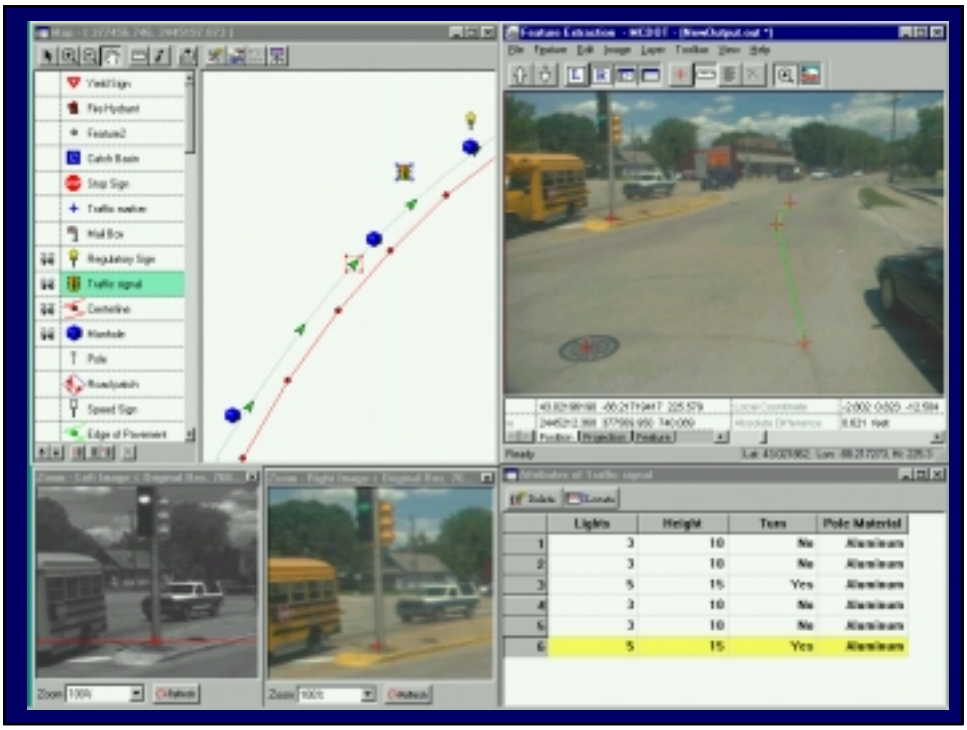
Positioning and Measuring



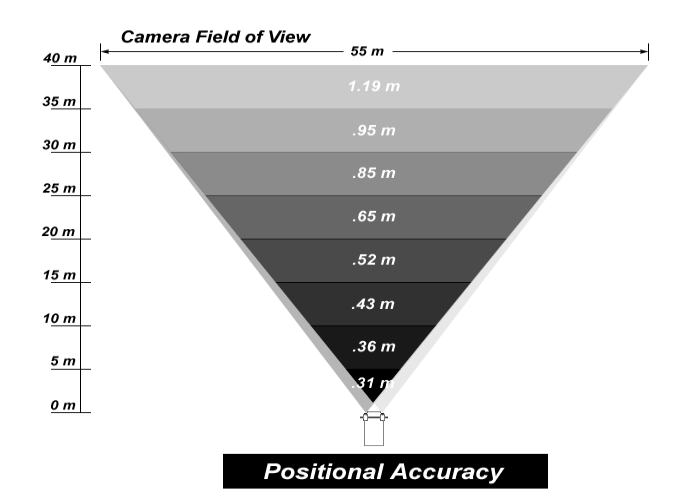
Zoom for Accurate Positioning

Points, Lines, Polygons and Data





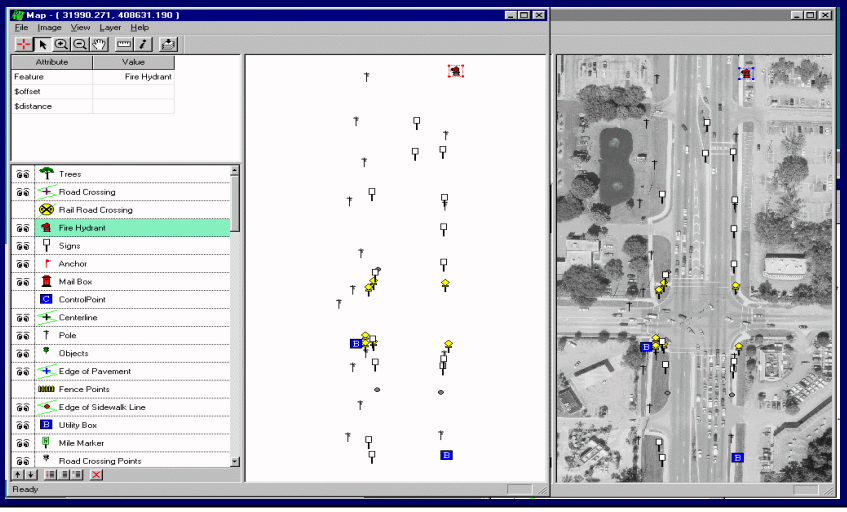
Positional Accuracy



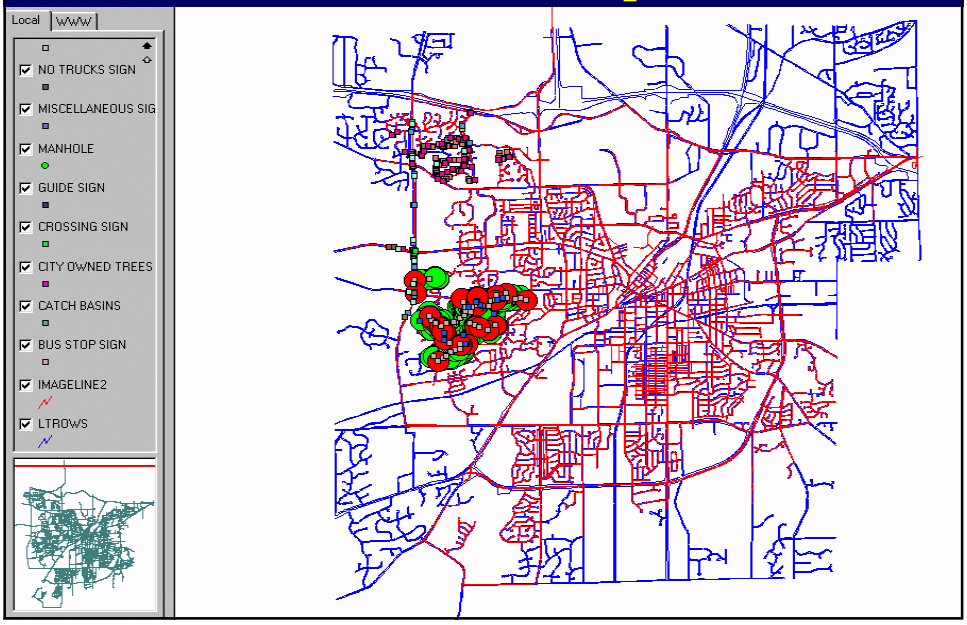
Relative Measurements

Aerials Rectified with GPSVision™ Imagery

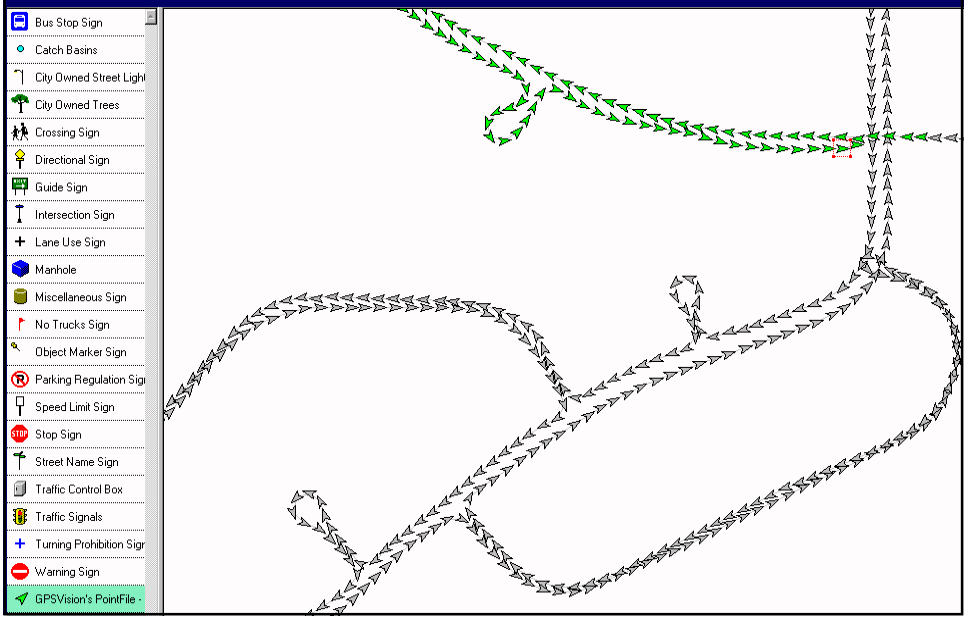
GPSVision™ Features Position Aerial Imagery



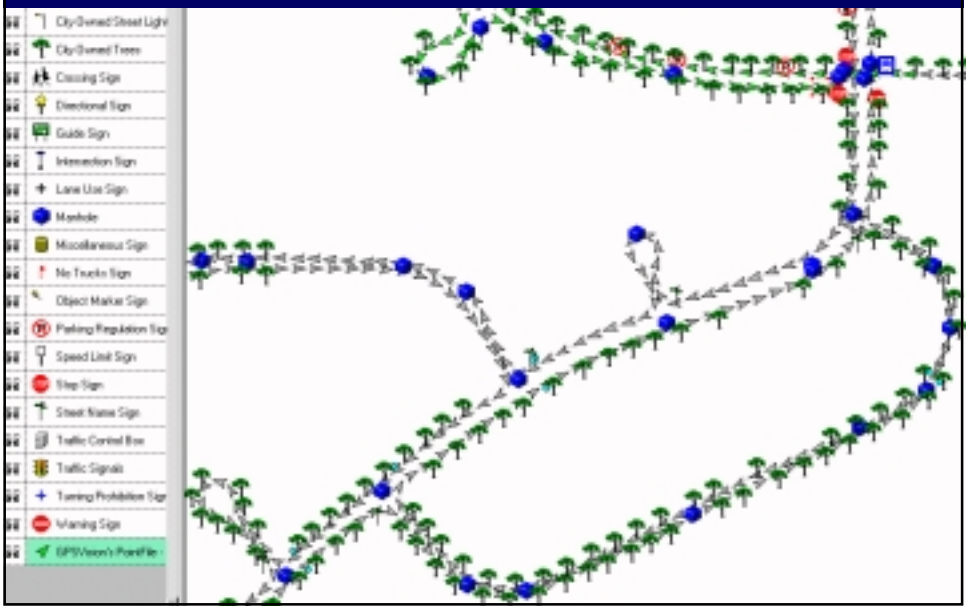
Overview Map



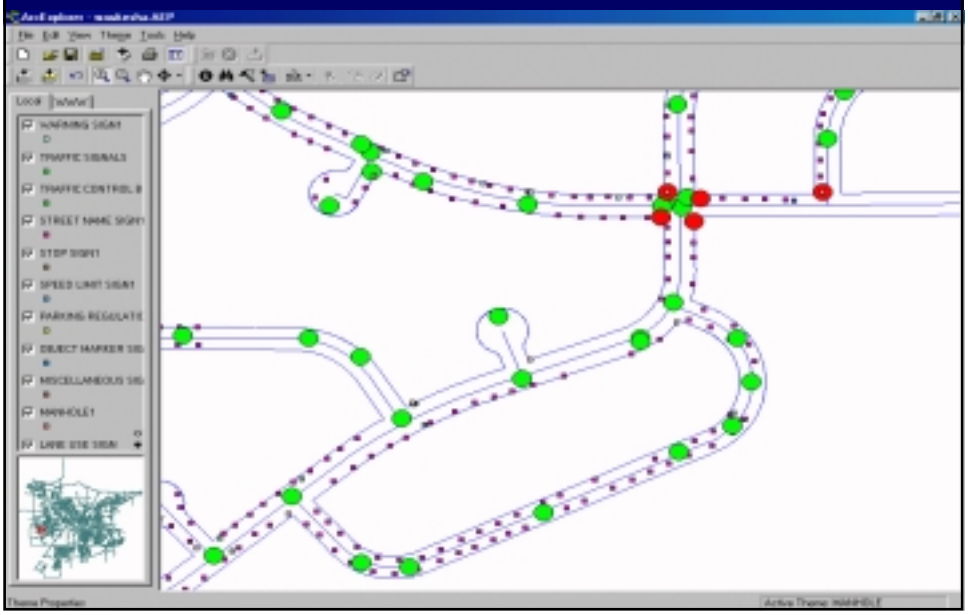
Points Where Images were Captured



Feature Extraction Output File

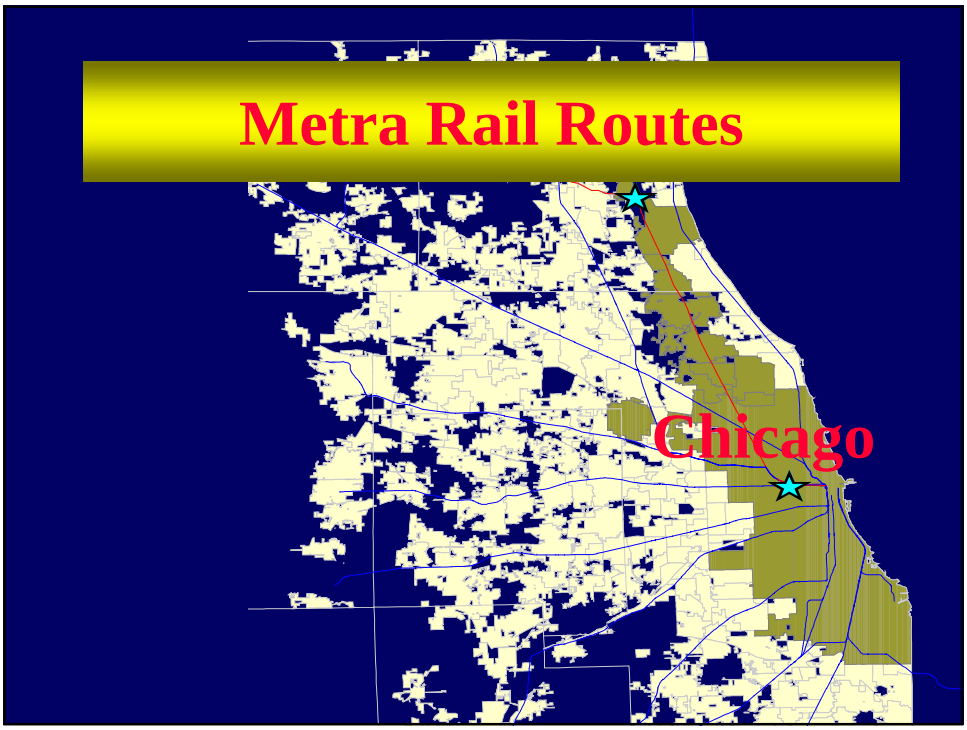


Features Overlaid on ROW Map



Geographic Information System in a Municipal Management Application


GPSVision for Chicago's
Metra Trains

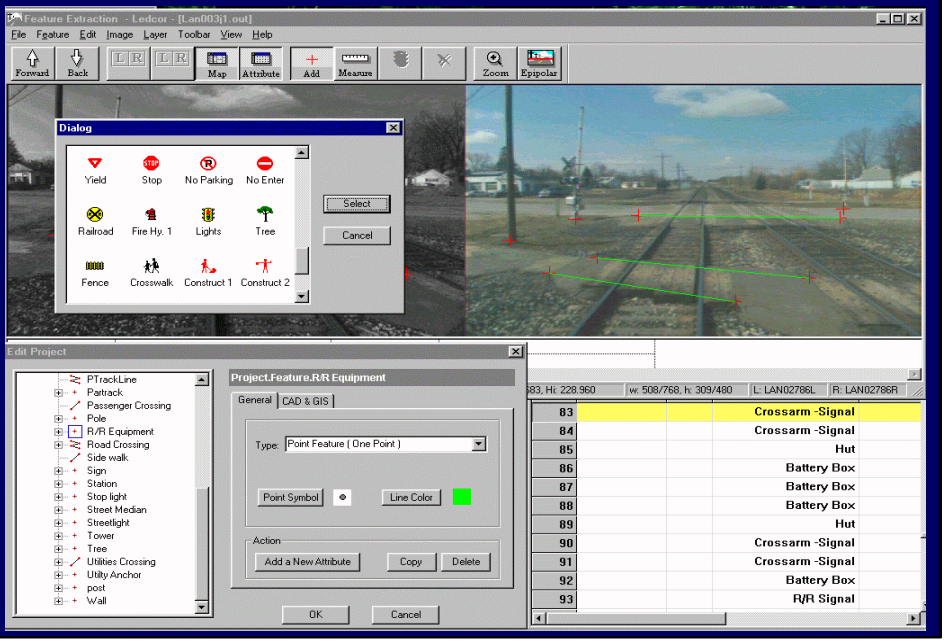

Metra Rail Routes
Chicago

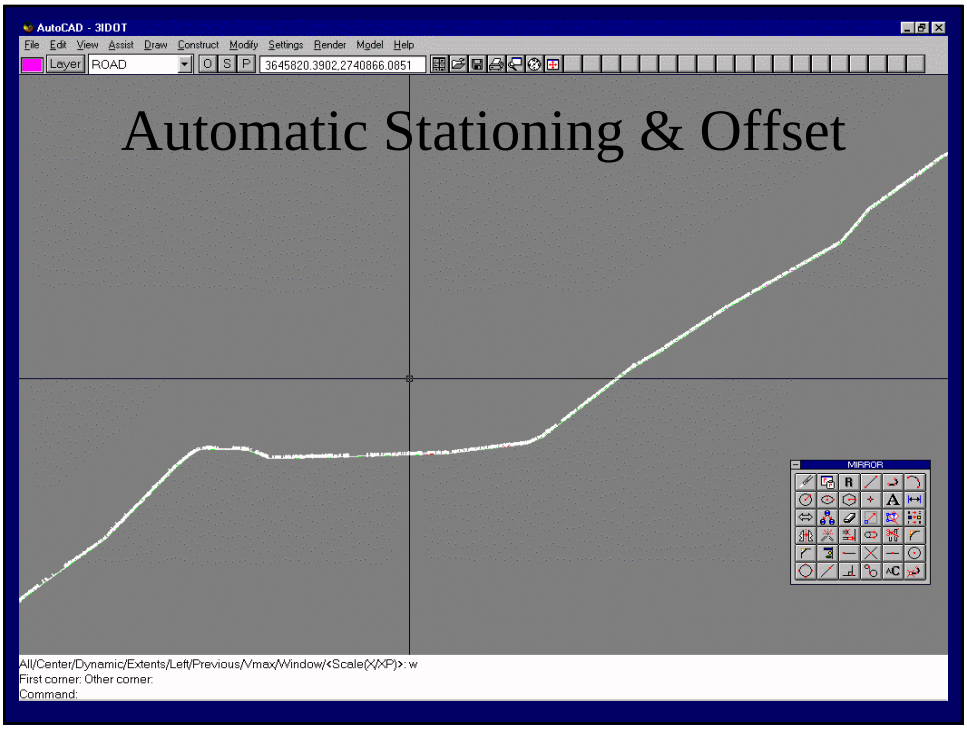
Transportable Cameras Aimed to Rear

Stereo Cameras and GPS

Feature Positioning

Define Features and Attributes

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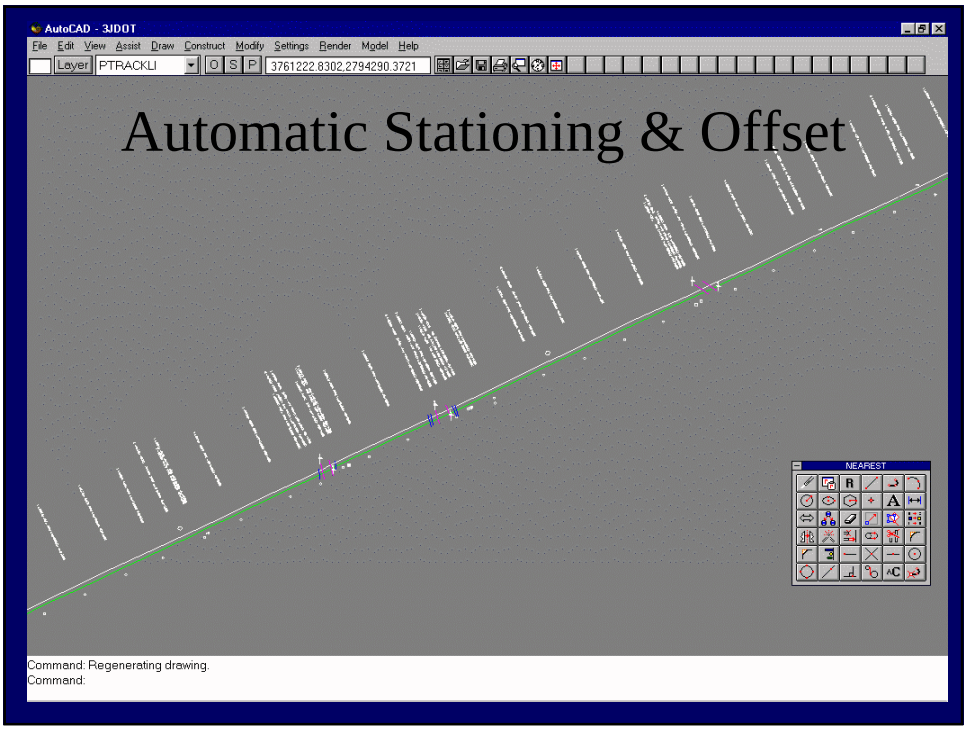
File Edit View Assist Draw Construct Modify Settings Render Model Help
Layer ROAD O S P 3645820.3902,2740866.0851
Automatic Stationing & Offset
MIRROR
All/Center/Dynamic/Extents/Left/Previous/Vmax/Window/<Scale(X/XP)>: w
First corner: Other corner:
Command: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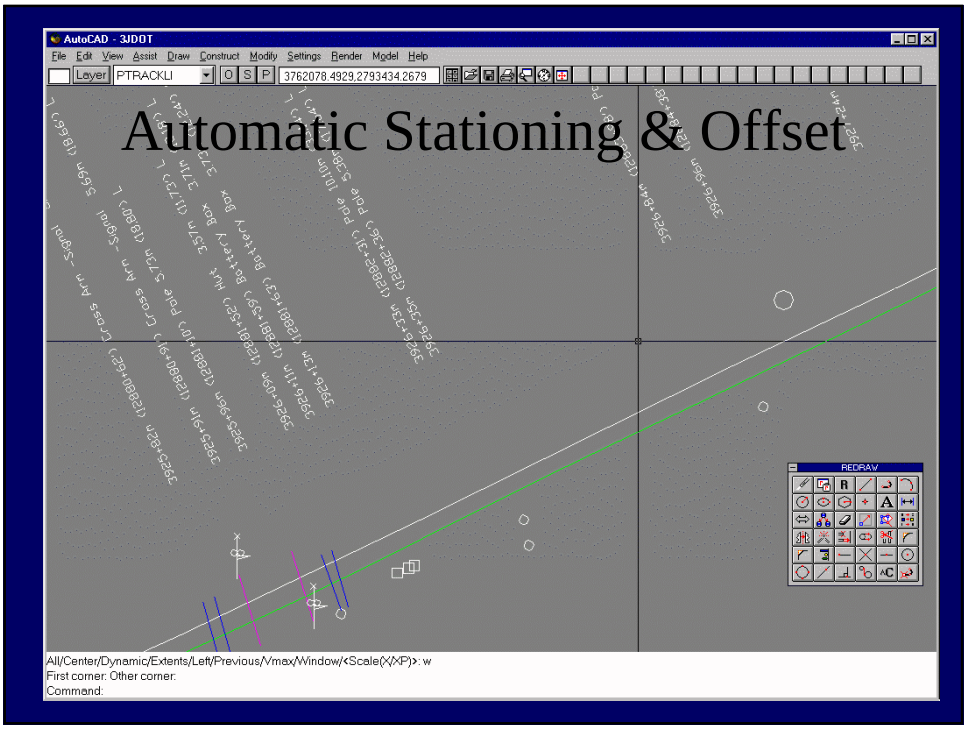
File Edit View Assist Draw Construct Modify Settings Render Model Help
Layer PTRACKLI O S P 3761222.8302,2794290.3721
Automatic Stationing & Offset
NEAREST
Command: Regenerating drawing.
Command:


AutoCAD - 3JDOT
File Edit View Assist Draw Construct Modify Settings Render Model Help
Layer PTRACKLI
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Automatic Stationing & Offset
REDRAW
All/Center/Dynamic/Extents/Left/Previous/Vmax/Window/<Scale(X/XP)>: w
First corner: Other corner:
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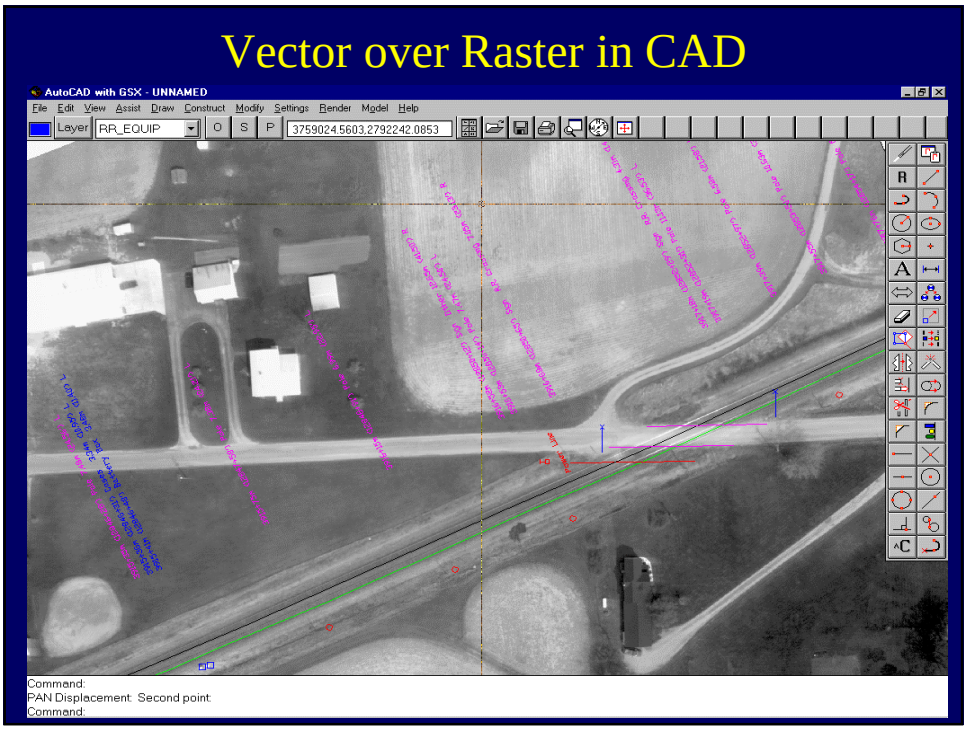
Vector over Raster in CAD
AutoCAD with GSX - UNNAMED
File Edit View Assist Draw Construct Modify Settings Render Model Help
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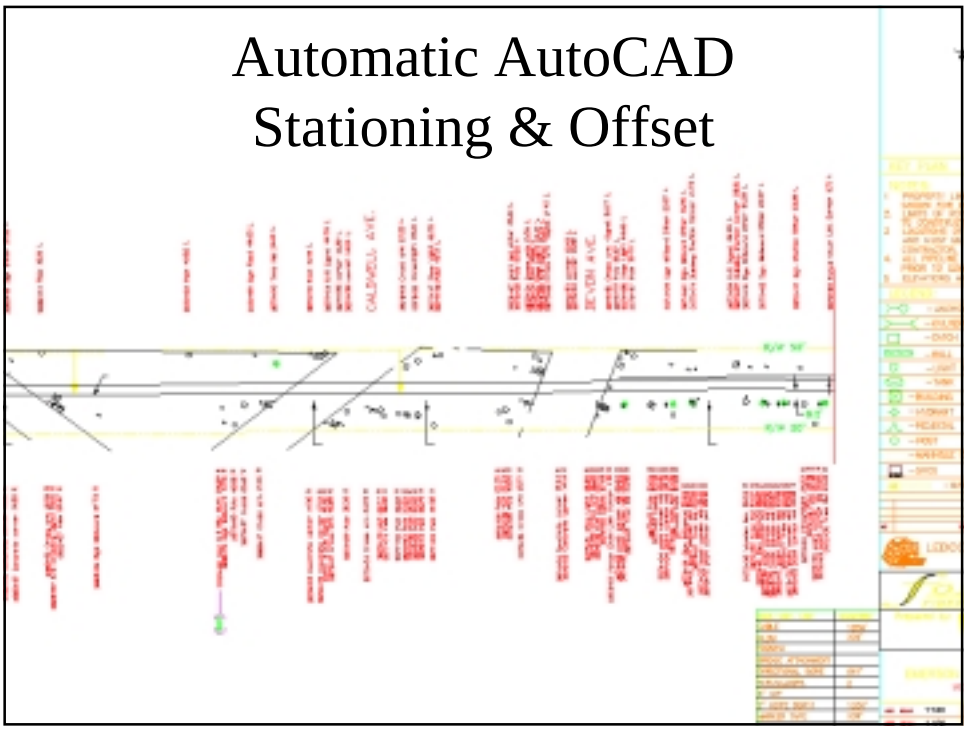
PAN Displacement: Second point:
Command:

Automatic AutoCAD Stationing & Offset



ROW Engineering

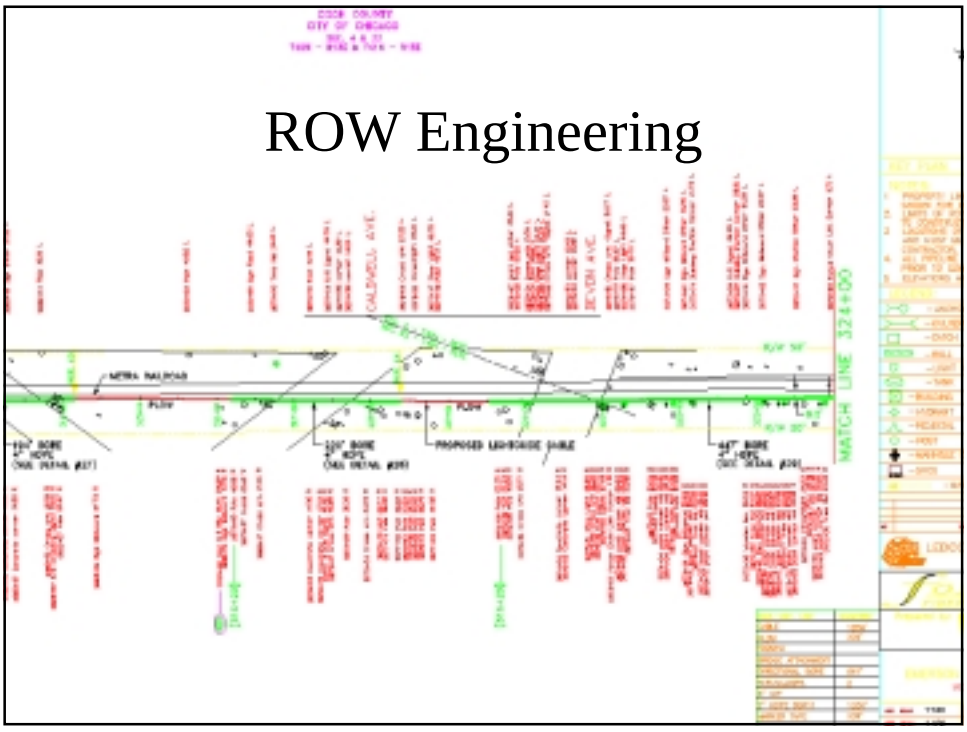
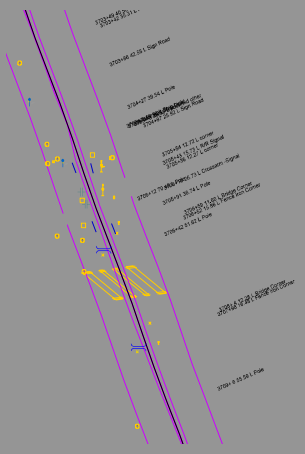


Photo Link to GIS



Thank You

GIS In Transportation Symposium 2001

Implementation of the Pennsylvania Turnpike's Executive Information Management System

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Presentation Objectives

I Provide an Overview of the PTC's Executive Information Management System (EIS);

II Discuss the Development and Implementation of the "Heart" of the EIS -- the PTC's GIS; and

III Demonstrate the PTC's EIS focusing on:

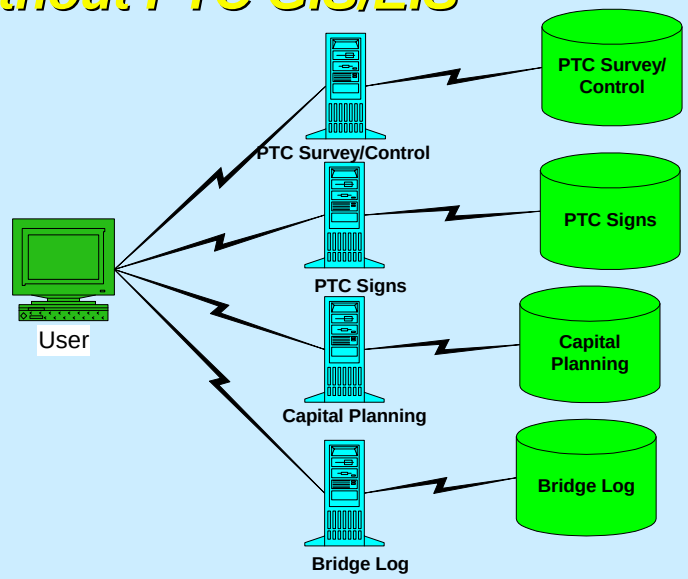
The System-Wide GIS

Integration of Databases and Applications

Motivation for the PTC EIS

- *Different development environments;*
- *"Individually owned" data and applications; and*
- *Proactive IT Department dedicated to data mining*

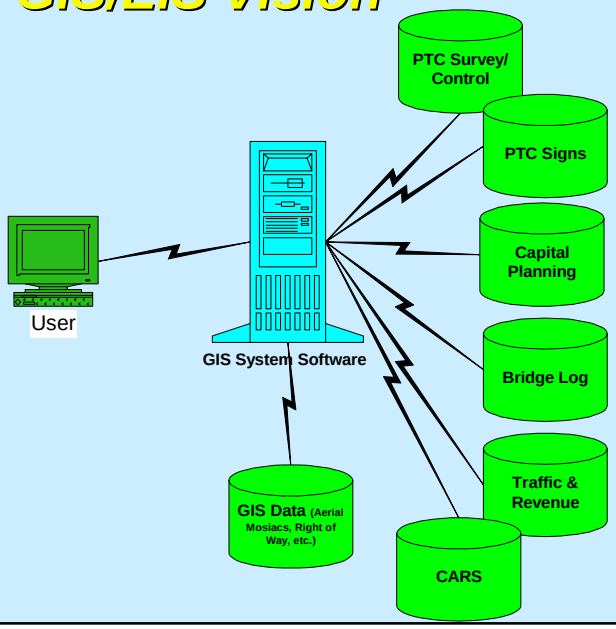
Without PTC GIS/EIS



Objectives of the PTC EIS

- *Provide a common "front-end" within a common development environment;*
- *Increase accessibility to data and applications;*
- *Foster the integration of all types of data; and*
- *Provide an easy to use application that required minimal training.*

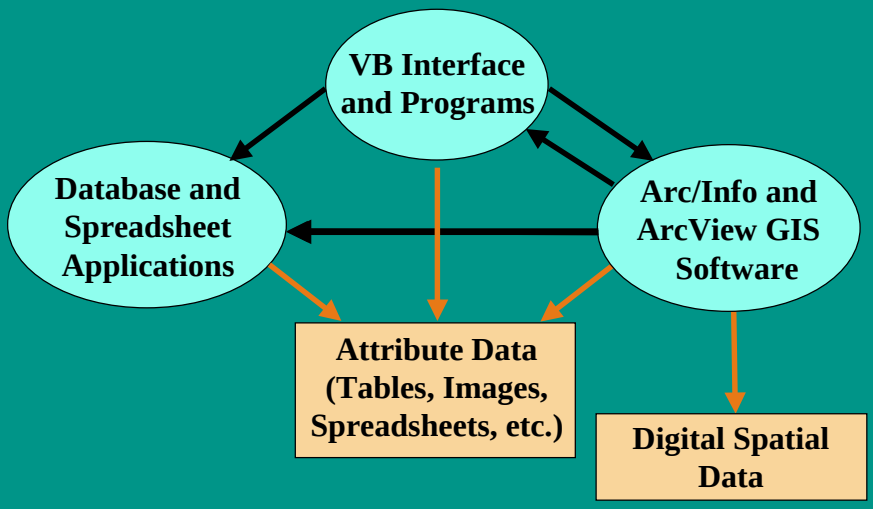
PTC GIS/EIS Vision



Five EIS Components

- *A Visual Basic Interface and Suite of Custom Applications*
- *Existing and Newly Developed PTC Database Applications*
- *Customized ARC/INFO and ArcView GIS Software -- the "Heart" of the EIS*
- *Attribute Data (both new and existing)*
- *Digital Spatial Data*

Schematic of the PTC's EIS



6 Step Implementation Strategy

- *Development of Digital Spatial Data*
- *Development of Complementary Coverages*
- *Dynamic Segmentation (Linear Referencing)*
- *Incorporation of Aerial Mosaics*
- *Customization*
- *Integration with Existing and Newly Developed Database Applications*

1. Develop Digital Spatial Data

- *Detailed AutoCAD As-Built Drawings Processed in Arc/Info*
- *Resulted in 12 feature coverages and 16 annotation coverages*

2. Preparation of Complementary Coverages

- ✔ *County Boundaries*
- ✔ *Minor Civil Division Boundaries*
- ✔ *Legislative Boundaries*
- ✔ *Road Centerlines within a 2 mile distance of PTC facilities*
- ✔ *Hydrography*

3. Dynamic Segmentation of Centerlines

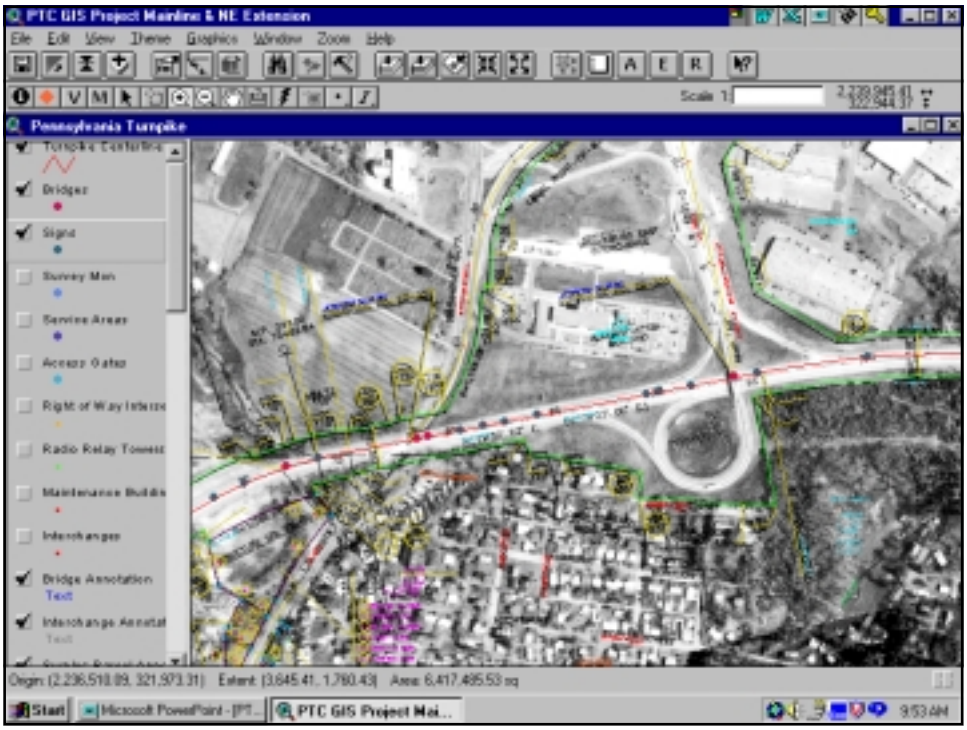
- *Centerlines for the Turnpike and all Extensions were converted to "routes" utilizing ARC/INFO's Dynamic Segmentation capabilities*
- *As a result, any feature for which the Route and Milepost location are known can be mapped*
- *Incorporates "non-standard" Miles.*

4. Synthesis of Aerial Mosaics

- *A 491 sheet aerial mosaic was developed for the PTC*
- *The 1:2400 scale photos were not rectified*
- *Geometry (from as-builts) plotted on each*
- *Used extensively by PTC staff*

Synthesis of Aerial Mosaics

- ✔ *Scanning*
- ✔ *Conversion to ARC/INFO Grids*
- ✔ *Transformation into spatially referenced grids by rotating, translating and warping each grid to match the centerline and legal right-of-way lines in the GIS coverages*



5. Examples of GIS Customization

- ✔ *Pull-Down menus to facilitate zooming to any spatial feature;*
- ✔ *The capability to automatically label mileposts;*
- ✔ *The ability to select data layers to be available for display and analysis;*
- ✔ *The ability to specify the database fields which are visible when a feature table is opened; and*
- ✔ *Integration of Existing Applications into GIS*

Benefits of Custom Programming

- *Enhances the functionality of GIS software*
- *Geographically enables database applications*
- *Provides access to the full power of a GIS without the need for extensive training*
- *Allows the users to focus on obtaining and synthesizing information rather than on learning new and complex software*

6. Integration wih Existing and Newly Developed Database Applications

- ✔ *Collision Analysis and Reporting System (CARS)*
  - ✔ *VB 6.0 Application with Oracle 8i Database (Developed by WEC)*
- ✔ *Computer Aided Dispatch System (CADS)*
  - ✔ *VB 6.0 and MapObjects Application with SQL 7.0 Database (Developed by another Vendor)*
- ✔ *PTC Capital Planning System*
  - ✔ *VB 6.0 Application with Oracle 7.3.4 Database (Developed by another Vendor)*

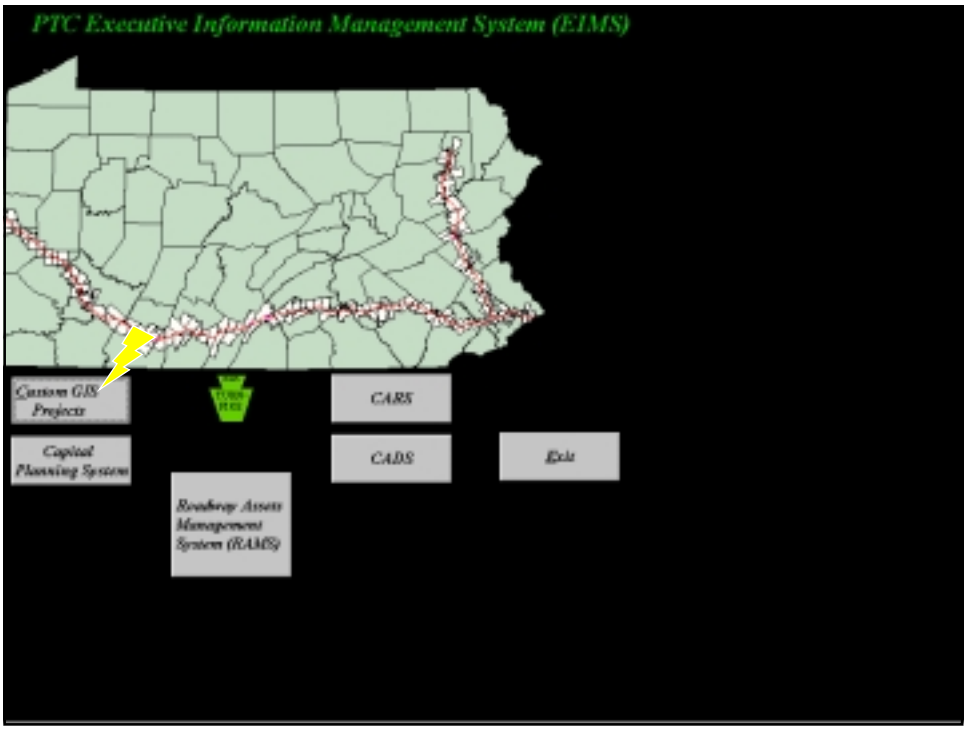
6. Integration wih Existing and Newly Developed Database Applications

- ✔ *Roadway Asset Management System (RAMS)*
  - ✔ *A VB 6.0 Application with an Oracle 8i Database developed by PTC Staff. Components include:*
    - ✔ *Sign Log*
    - ✔ *Sign Structures*
    - ✔ *Bridge Log*
    - ✔ *Facility Log*
    - ✔ *Pavement Management System*

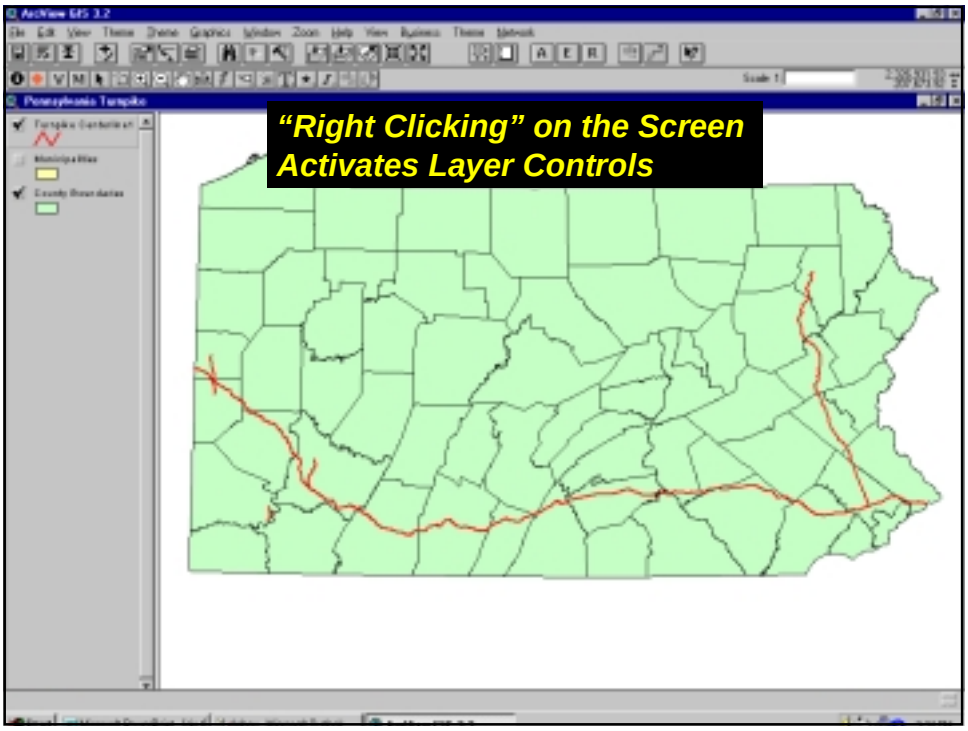
Resultant Benefits

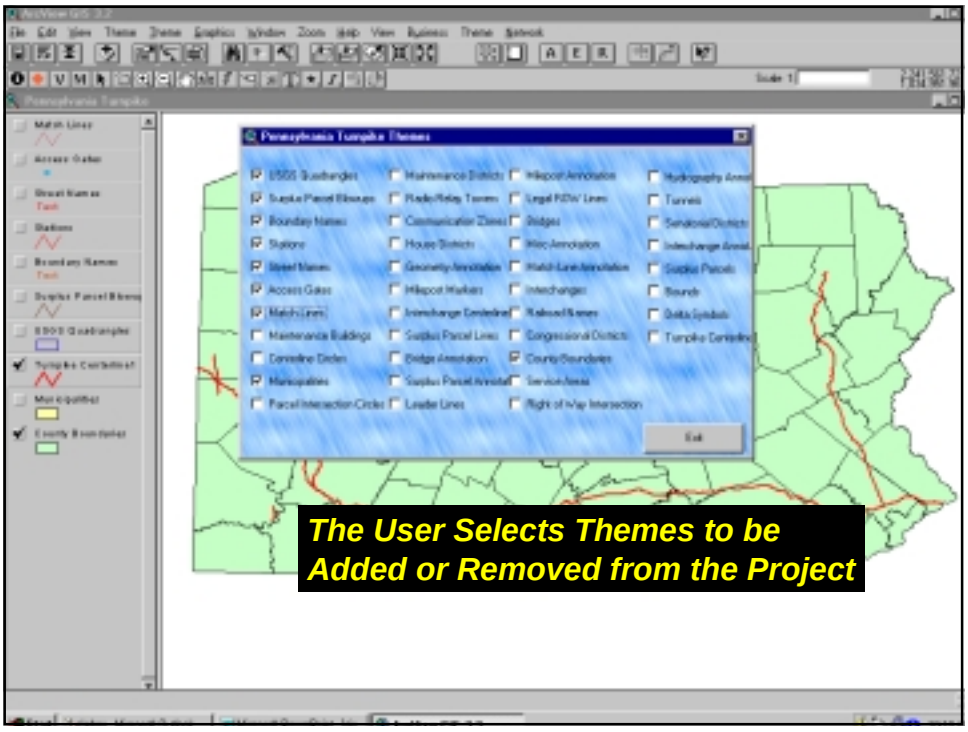
- ✔ *All authorized workstations on the network have access to all databases directly from the GIS*
- ✔ *Data integrity and security are maintained because database files can be rendered "read only"*
- ✔ *Select Applications can be accessed directly from the GIS*
- ✔ *Spatial Queries and Analyses can now be performed*
- ✔ *For the first time, various combinations of data can be mapped and viewed simultaneously*

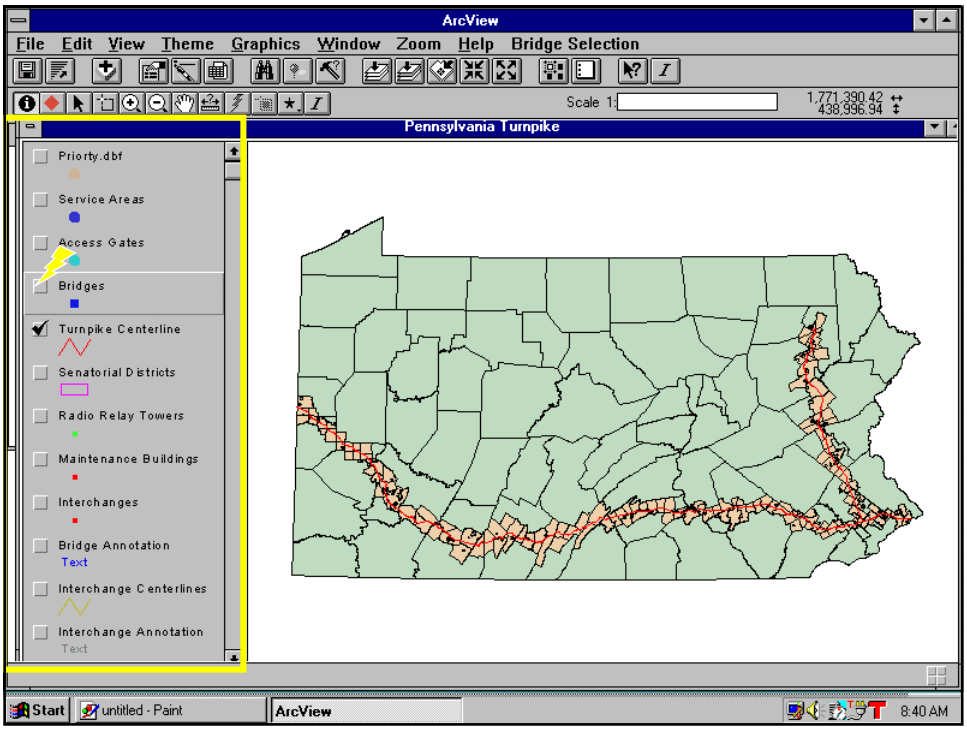
"Psuedo-Demonstration" of GIS and its Integration with Enterprise Databases and Applications

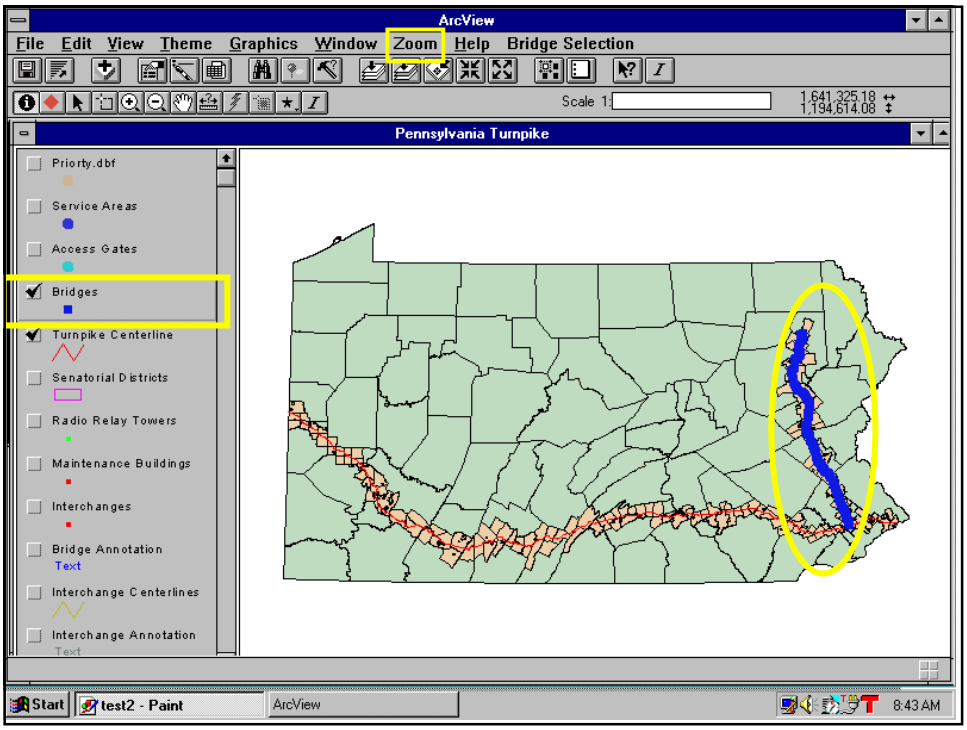

PTC Executive Information Management System (EIMS)
Custom GIS Projects
CARS
Capital Planning System
CADS
Exit
Roadway Assets Management System (RAMS)


Pennsylvania Turnpike Commission
PENNA TURN-PIKE
PA TURNPIKE
Beaver Valley
A.K. Hutchinson
Mon-Fayette
Mainline and
Overview
Exit Application
EXIT
GIS Applications
PENNSYLVANIA TURNPIKE COMMISSION


"Right Clicking" on the Screen
Activates Layer Controls


The User Selects Themes to be
Added or Removed from the Project


ArcView
File Edit View Theme Graphics Window Zoom Help Bridge Selection
Scale 1:
1,771,390.42
438,996.94
Pennsylvania Turnpike
Priorty.dbf
Service Areas
Access Gates
Bridges
Turnpike Centerline
Senatorial Districts
Radio Relay Towers
Maintenance Buildings
Interchanges
Bridge Annotation
Text
Interchange Centerlines
Interchange Annotation
Text
Start
untitled - Paint
ArcView
8:40 AM


ArcView
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Scale 1:
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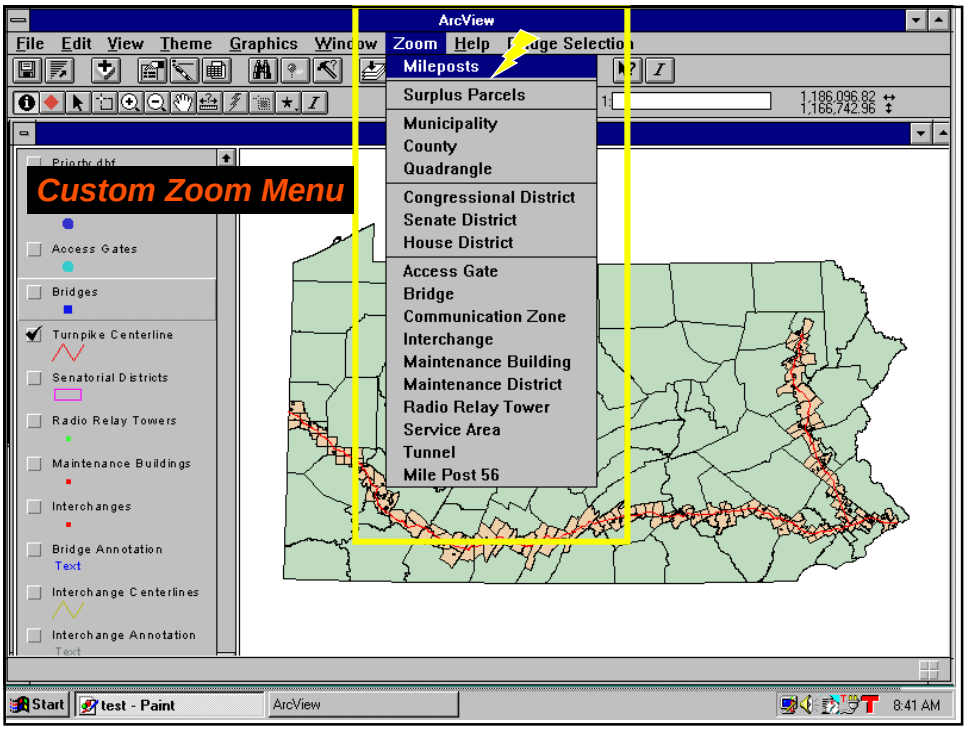
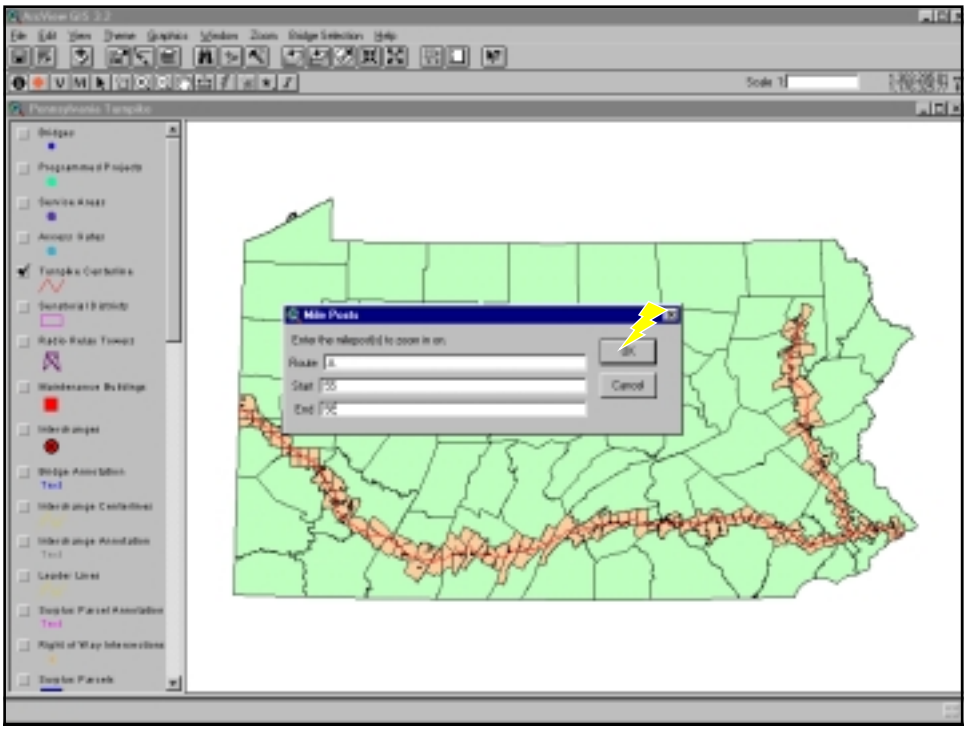
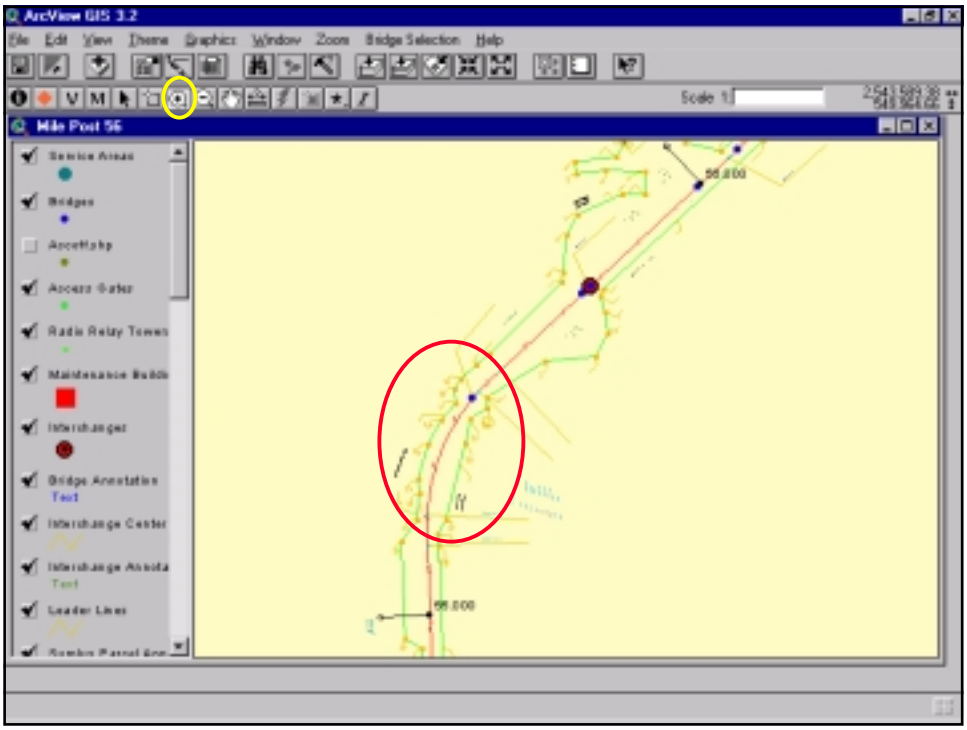
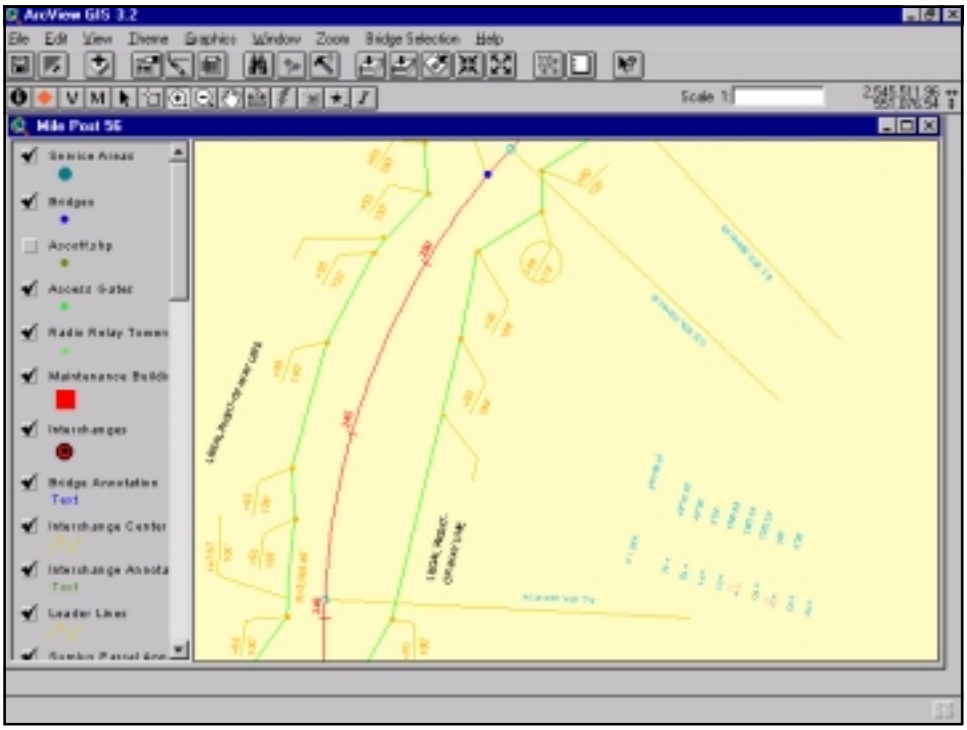
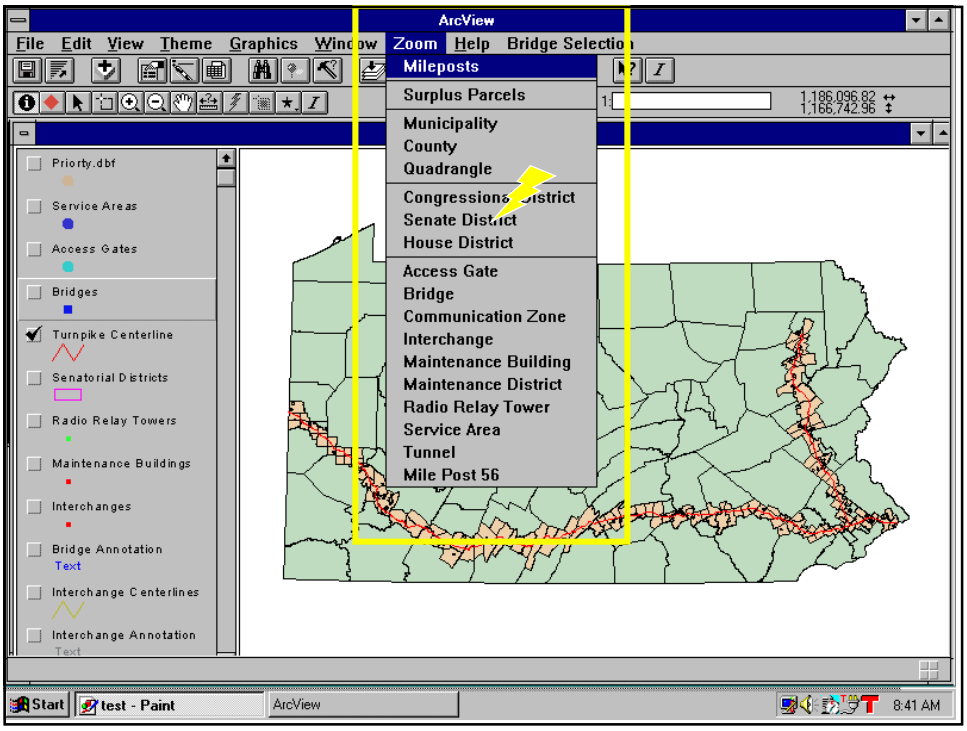
Pennsylvania Turnpike
Priorty.dbf
Service Areas
Access Gates
Bridges
Turnpike Centerline
Senatorial Districts
Radio Relay Towers
Maintenance Buildings
Interchanges
Bridge Annotation
Text
Interchange Centerlines
Interchange Annotation
Text
Start
test2 - Paint
ArcView
8:43 AM

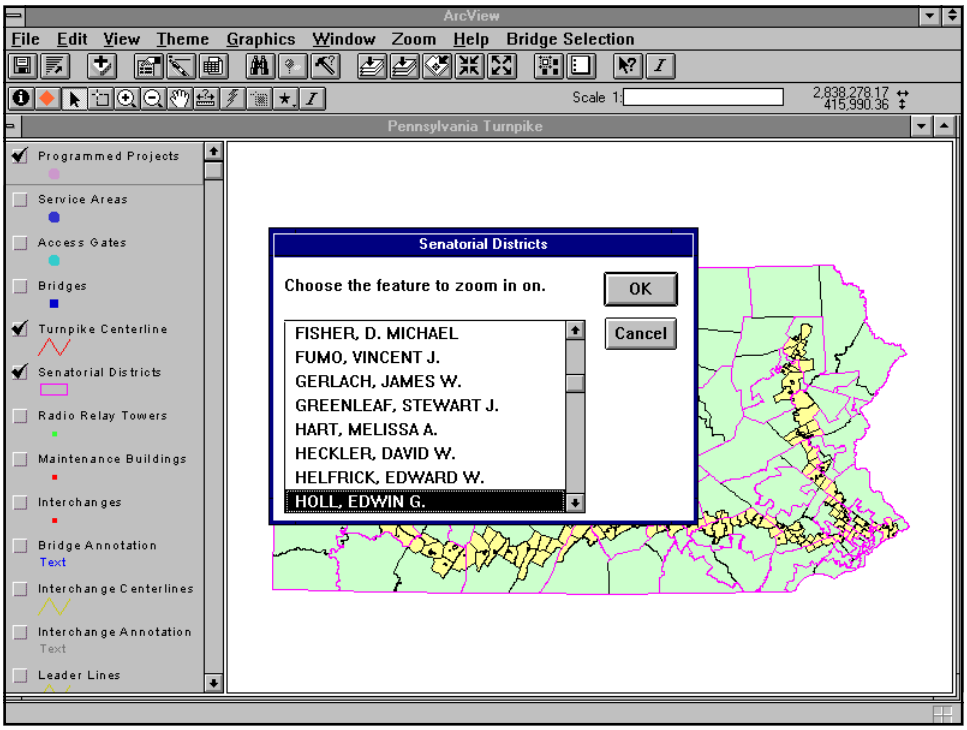

ArcView
File Edit View Theme Graphics Window Zoom Help
Mileposts
Surplus Parcels
Municipality
County
Quadrangle
Congressional District
Senate District
House District
Access Gate
Bridge
Communication Zone
Interchange
Maintenance Building
Maintenance District
Radio Relay Tower
Service Area
Tunnel
Mile Post 56
Custom Zoom Menu
Access Gates
Bridges
Turnpike Centerline
Senatorial Districts
Radio Relay Towers
Maintenance Buildings
Interchanges
Bridge Annotation
Interchange Centerlines
Interchange Annotation
Start
test - Paint
ArcView
8:41 AM




ArcView GIS 3.2
File Edit View Theme Graphics Window Zoom Bridge Selection Help
Scale 1:
Mile Post 56
Service Areas
Bridges
Access Gates
Radio Relay Towers
Interchanges
Bridge Annotation
Text
Interchange Centers
Leader Lines


ArcView GIS 3.2
File Edit View Theme Graphics Window Zoom Bridge Selection Help
Scale 1:
Mile Post 56
Service Areas
Bridges
Access Gates
Radio Relay Towers
Interchanges
Bridge Annotation
Text
Interchange Centers
Leader Lines


ArcView
File Edit View Theme Graphics Window Zoom Help Bridge Selection
Mileposts
Surplus Parcels
Municipality
County
Quadrangle
Congressional District
Senate District
House District
Access Gate
Bridge
Communication Zone
Interchange
Maintenance Building
Maintenance District
Radio Relay Tower
Service Area
Tunnel
Mile Post 56
Priorty.dbf
Service Areas
Access Gates
Bridges
Turnpike Centerline
Senatorial Districts
Radio Relay Towers
Maintenance Buildings
Interchanges
Bridge Annotation
Text
Interchange Centerlines
Interchange Annotation
Text
1,186,096.82
1,166,742.96
Start
test - Paint
ArcView
8:41 AM


ArcView
File Edit View Theme Graphics Window Zoom Help Bridge Selection
Scale 1:
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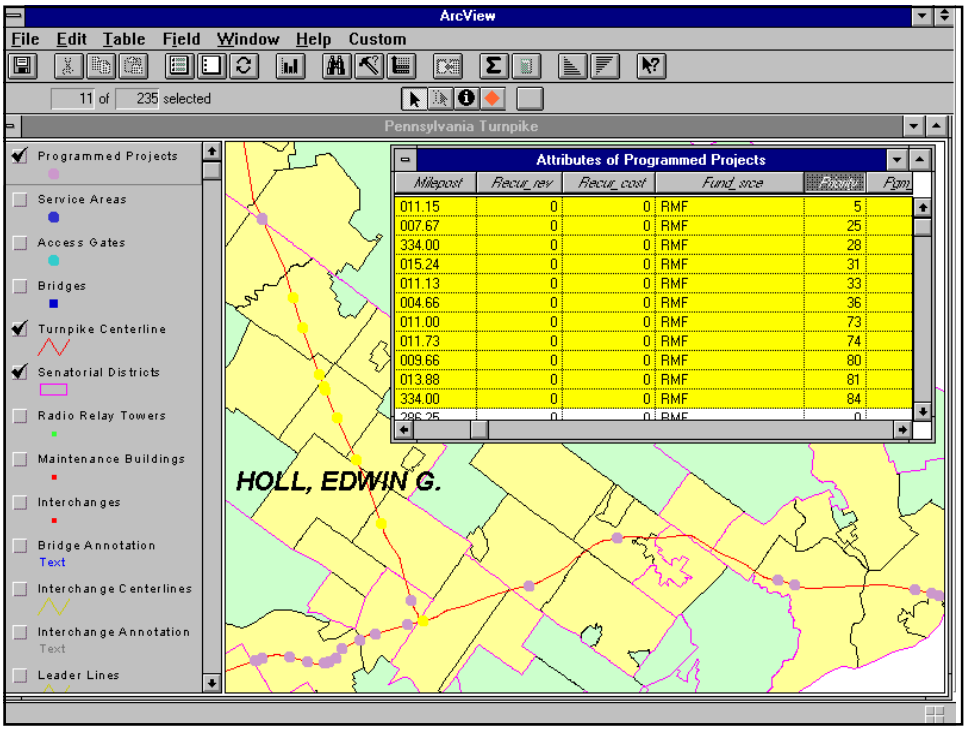
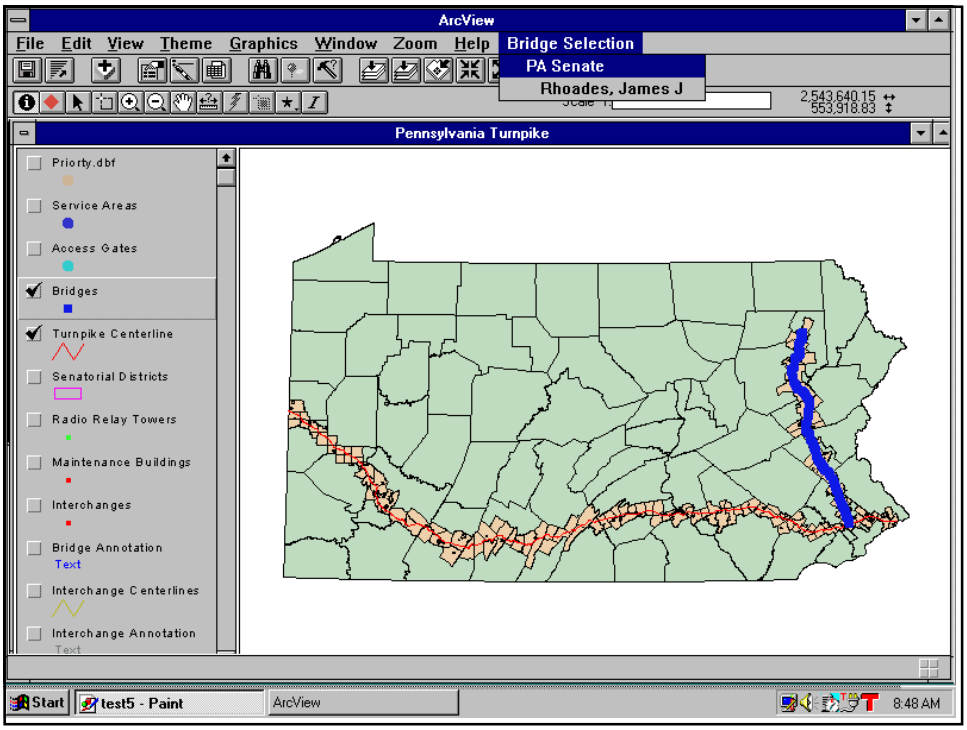
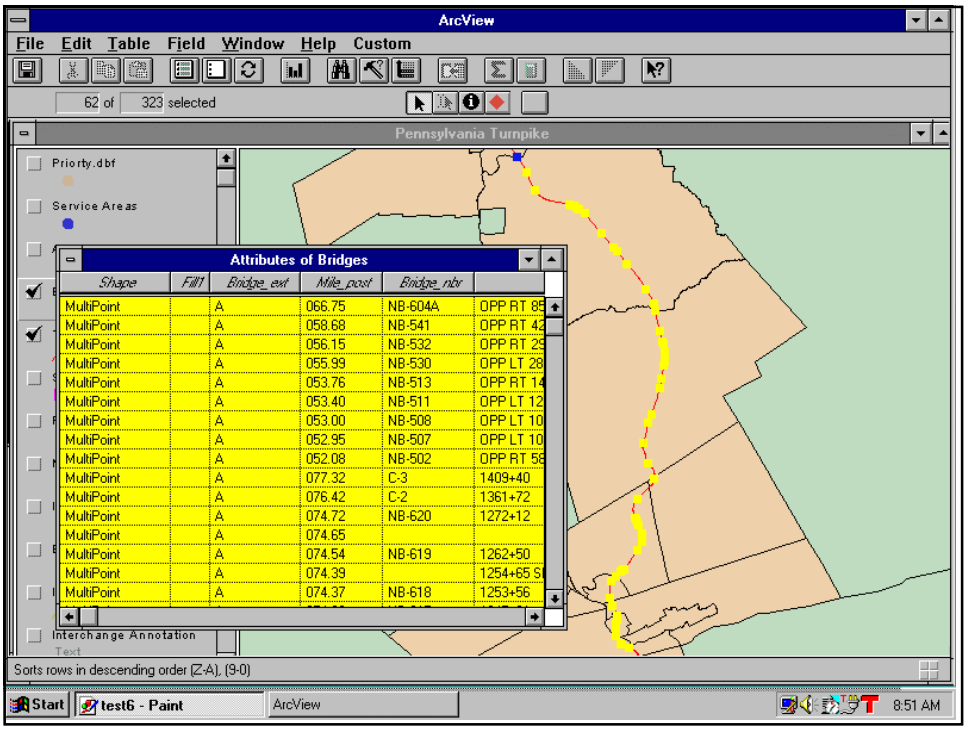
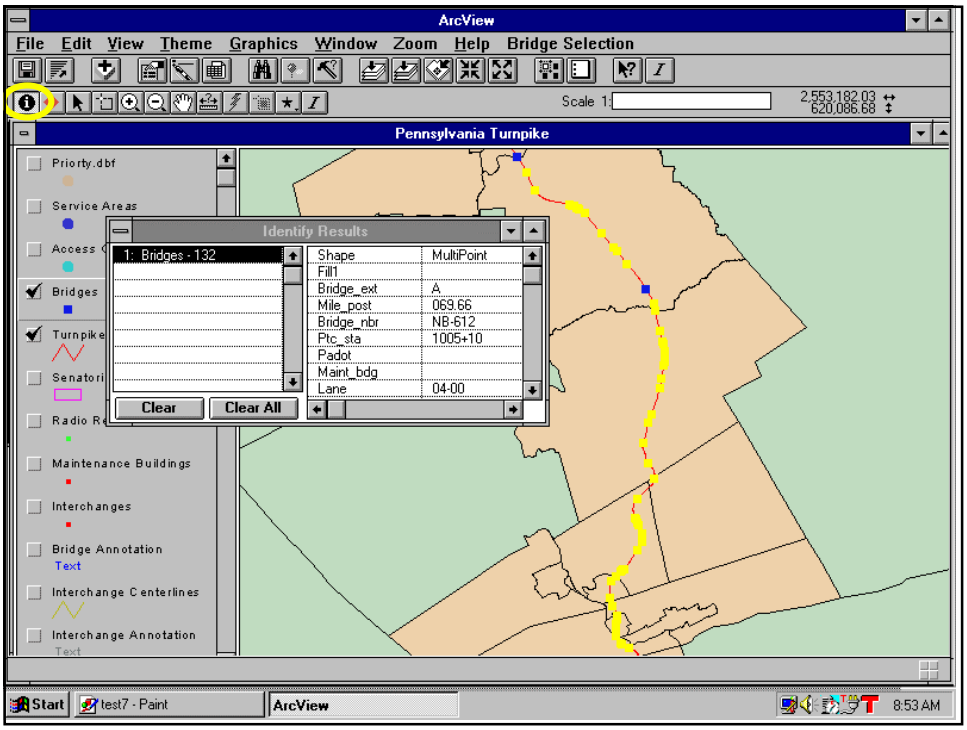
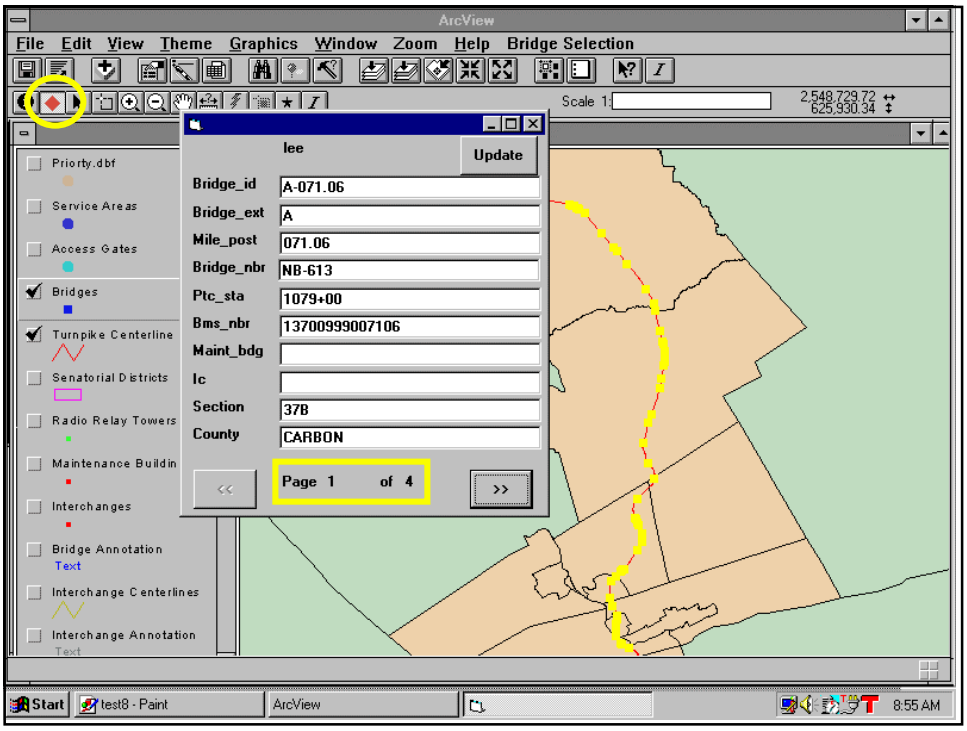
415,990.36
Pennsylvania Turnpike
Programmed Projects
Service Areas
Access Gates
Bridges
Turnpike Centerline
Senatorial Districts
Radio Relay Towers
Maintenance Buildings
Interchanges
Bridge Annotation
Text
Interchange Centerlines
Interchange Annotation
Text
Leader Lines
Senatorial Districts
Choose the feature to zoom in on.
OK
Cancel
FISHER, D. MICHAEL
FUMO, VINCENT J.
GERLACH, JAMES W.
GREENLEAF, STEWART J.
HART, MELISSA A.
HECKLER, DAVID W.
HELFRICK, EDWARD W.
HOLL, EDWIN G.

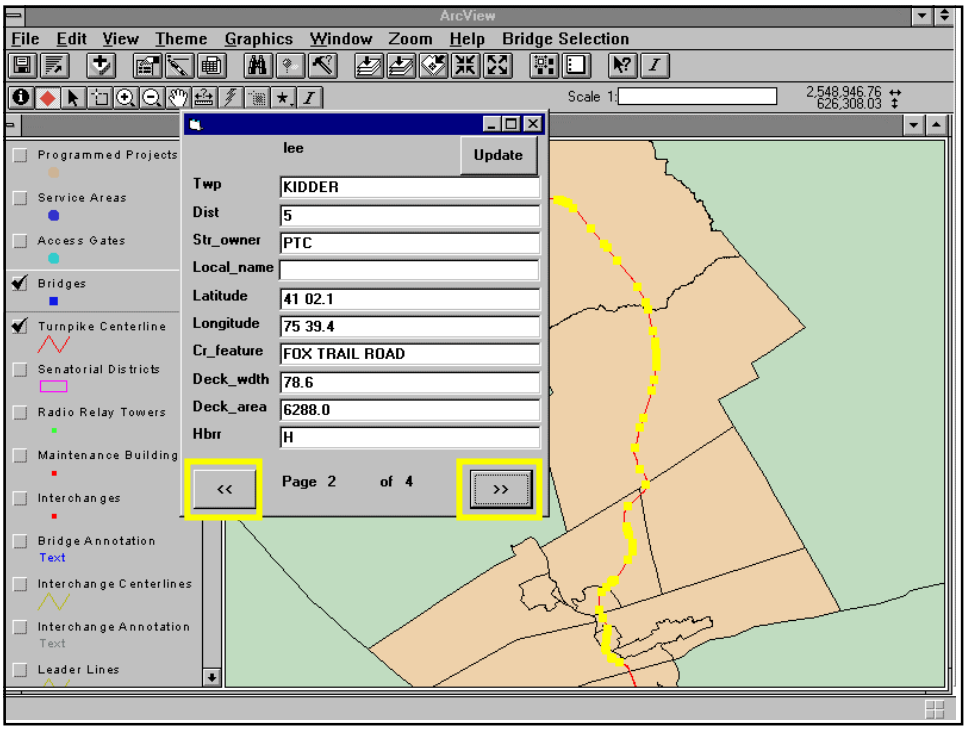

ArcView
File Edit Table Field Window Help Custom
11 of 235 selected
Pennsylvania Turnpike
Programmed Projects
Service Areas
Access Gates
Bridges
Turnpike Centerline
Senatorial Districts
Radio Relay Towers
Maintenance Buildings
Interchanges
Bridge Annotation
Text
Interchange Centerlines
Interchange Annotation
Text
Leader Lines
Attributes of Programmed Projects
Milepost Recur_rev Recur_cost Fund_srce Fam
011.15 0 0 RMF 5
007.67 0 0 RMF 25
334.00 0 0 RMF 28
015.24 0 0 RMF 31
011.13 0 0 RMF 33
004.66 0 0 RMF 36
011.00 0 0 RMF 73
011.73 0 0 RMF 74
009.66 0 0 RMF 80
013.88 0 0 RMF 81
334.00 0 0 RMF 84
HOLL, EDWIN G.

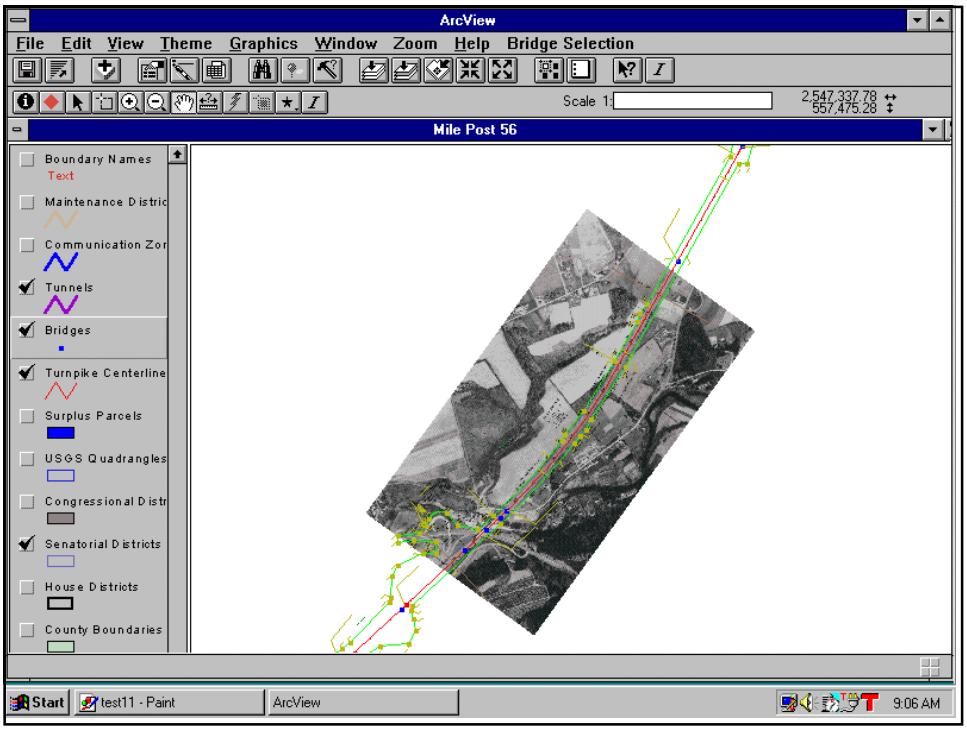

ArcView
File Edit View Theme Graphics Window Zoom Help Bridge Selection
PA Senate
Rhoades, James J
2,543,640.15
553,918.83
Pennsylvania Turnpike
Priority.dbf
Service Areas
Access Gates
Bridges
Turnpike Centerline
Senatorial Districts
Radio Relay Towers
Maintenance Buildings
Interchanges
Bridge Annotation
Text
Interchange Centerlines
Interchange Annotation
Text
Start
test5 - Paint
ArcView
8:48 AM

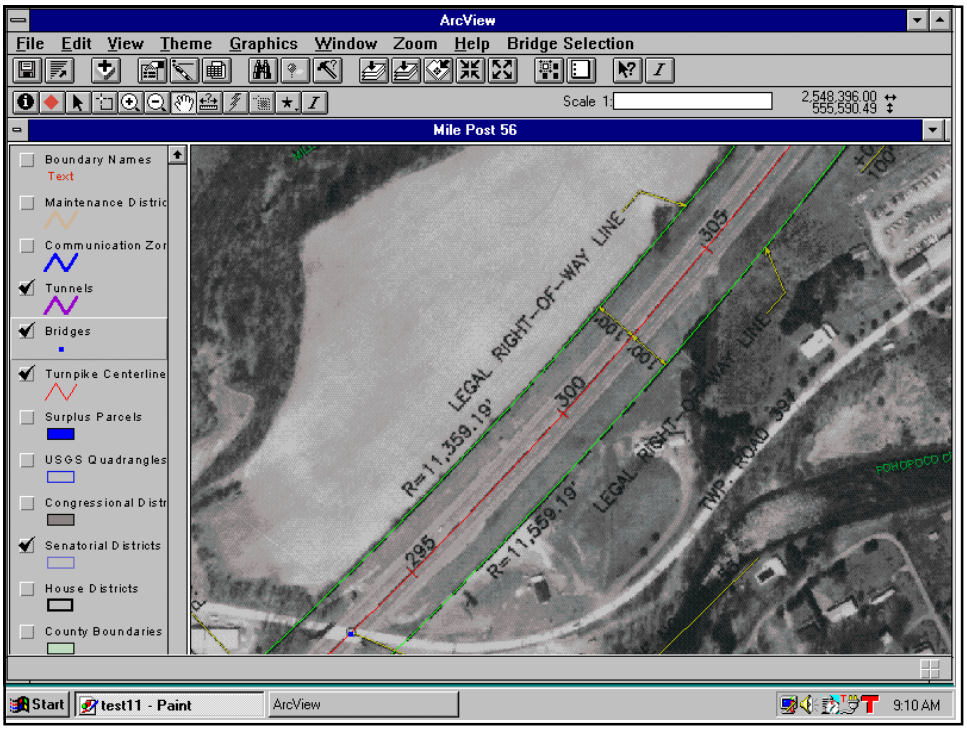

ArcView
File Edit Table Field Window Help Custom
62 of 323 selected
Pennsylvania Turnpike
Priority.dbf
Service Areas
Attributes of Bridges
Shape Fill1 Bridge_ext Mile_post Bridge_nbr
MultiPoint A 066.75 NB-604A OPP RT 85
MultiPoint A 058.68 NB-541 OPP RT 42
MultiPoint A 056.15 NB-532 OPP RT 29
MultiPoint A 055.99 NB-530 OPP LT 28
MultiPoint A 053.76 NB-513 OPP RT 14
MultiPoint A 053.40 NB-511 OPP LT 12
MultiPoint A 053.00 NB-508 OPP LT 10
MultiPoint A 052.95 NB-507 OPP LT 10
MultiPoint A 052.08 NB-502 OPP RT 58
MultiPoint A 077.32 C-3 1409+40
MultiPoint A 076.42 C-2 1361+72
MultiPoint A 074.72 NB-620 1272+12
MultiPoint A 074.65
MultiPoint A 074.54 NB-619 1262+50
MultiPoint A 074.39 1254+65.5
MultiPoint A 074.37 NB-618 1253+56
Interchange Annotation
Text
Sorts rows in descending order (Z-A), (9-0)
Start
test6 - Paint
ArcView
8:51 AM

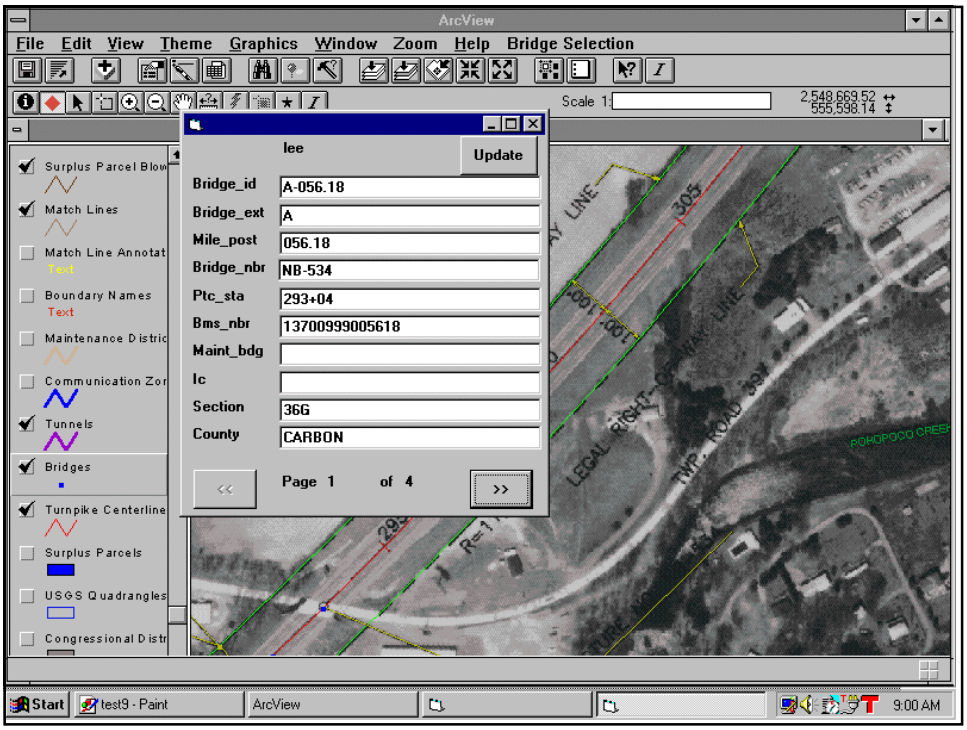

ArcView
File Edit View Theme Graphics Window Zoom Help Bridge Selection
Scale 1:
2,553,182.03
620,086.68
Pennsylvania Turnpike
Priority.dbf
Service Areas
Access
Bridges
Turnpike
Senatori
Radio Re
Maintenance Buildings
Interchanges
Bridge Annotation
Text
Interchange Centerlines
Interchange Annotation
Text
Identify Results
1: Bridges - 132
Shape MultiPoint
Fill1
Bridge_ext A
Mile_post 069.66
Bridge_nbr NB-612
Ptc_sta 1005+10
Padot
Maint_bdg
Lane 04-00
Clear
Clear All
Start
test7 - Paint
ArcView
8:53 AM


ArcView
File Edit View Theme Graphics Window Zoom Help Bridge Selection
Scale 1:
2,548,729.72
625,930.34
lee
Update
Bridge_id A-071.06
Bridge_ext A
Mile_post 071.06
Bridge_nbr NB-613
Ptc_sta 1079+00
Bms_nbr 13700999007106
Maint_bdg
Ic
Section 37B
County CARBON
<<
Page 1 of 4
>>
Priorty.dbf
Service Areas
Access Gates
Bridges
Turnpike Centerline
Senatorial Districts
Radio Relay Towers
Maintenance Buildin
Interchanges
Bridge Annotation
Text
Interchange Centerlines
Interchange Annotation
Text
Start
test8 - Paint
ArcView
8:55 AM


ArcView
File Edit View Theme Graphics Window Zoom Help Bridge Selection
Scale 1:
2,548,946.76
626,308.03
lee
Update
Twp KIDDER
Dist 5
Str_owner PTC
Local_name
Latitude 41 02.1
Longitude 75 39.4
Cr_feature FOX TRAIL ROAD
Deck_wdth 78.6
Deck_area 6288.0
Hbrr H
<<
Page 2 of 4
>>
Programmed Projects
Service Areas
Access Gates
Bridges
Turnpike Centerline
Senatorial Districts
Radio Relay Towers
Maintenance Building
Interchanges
Bridge Annotation
Text
Interchange Centerlines
Interchange Annotation
Text
Leader Lines


ArcView
File Edit View Theme Graphics Window Zoom Help Bridge Selection
Scale 1:
2,547,337.78
557,475.28
Mile Post 56
Boundary Names
Text
Maintenance Distric
Communication Zor
Tunnels
Bridges
Turnpike Centerline
Surplus Parcels
USGS Quadrangles
Congressional Distr
Senatorial Districts
House Districts
County Boundaries
Start
test11 - Paint
ArcView
9:06 AM


ArcView
File Edit View Theme Graphics Window Zoom Help Bridge Selection
Scale 1:
2,548,396.00
555,590.49
Mile Post 56
Boundary Names
Text
Maintenance Distric
Communication Zor
Tunnels
Bridges
Turnpike Centerline
Surplus Parcels
USGS Quadrangles
Congressional Distr
Senatorial Districts
House Districts
County Boundaries
LEGAL RIGHT-OF-WAY LINE
R=11,359.19'
R=11,559.19'
305
300
295
TWP. ROAD 391
Start
test11 - Paint
ArcView
9:10 AM



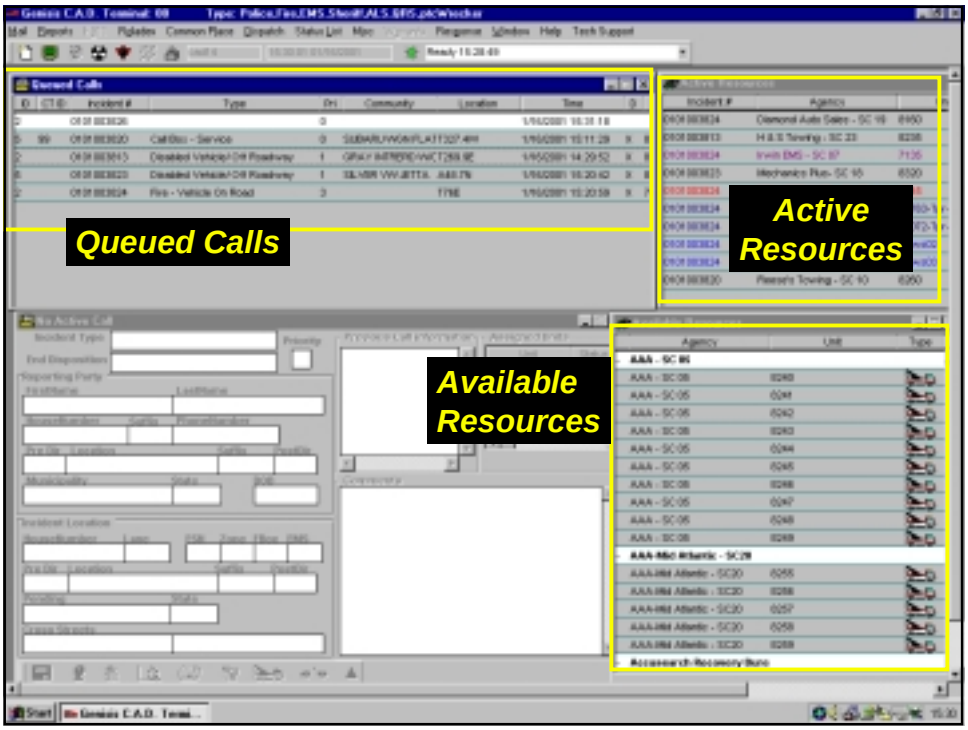
Integration of Enterprise Applications and Databases

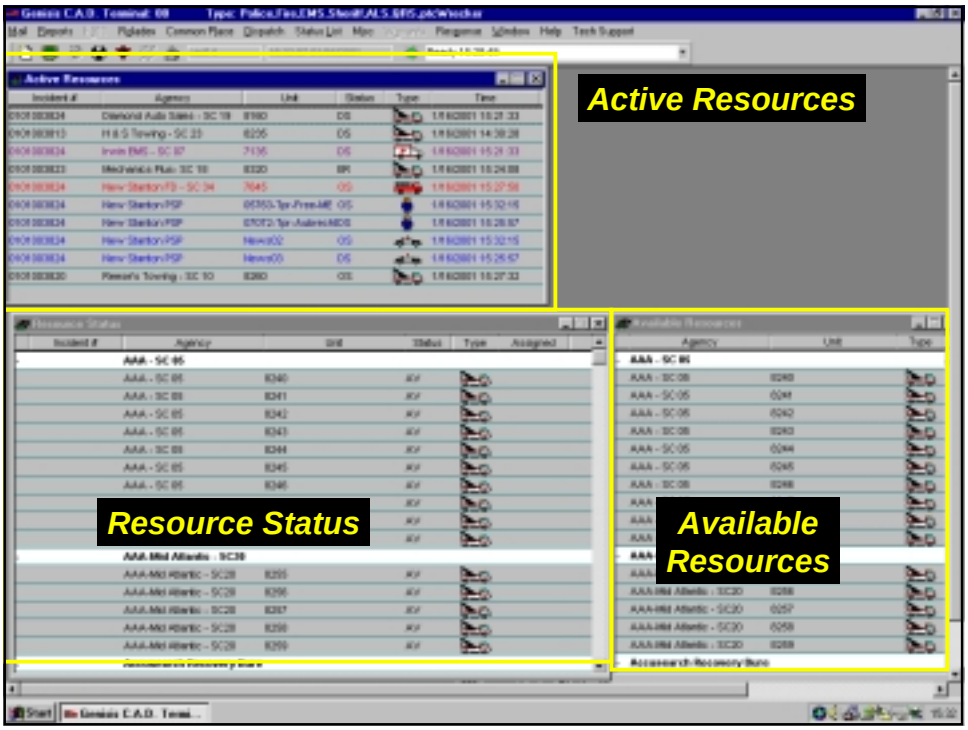
- *Integration of Databases for the Computer Aided Dispatch System (CADS) and the Crash Analysis and Reporting System (CARS)*

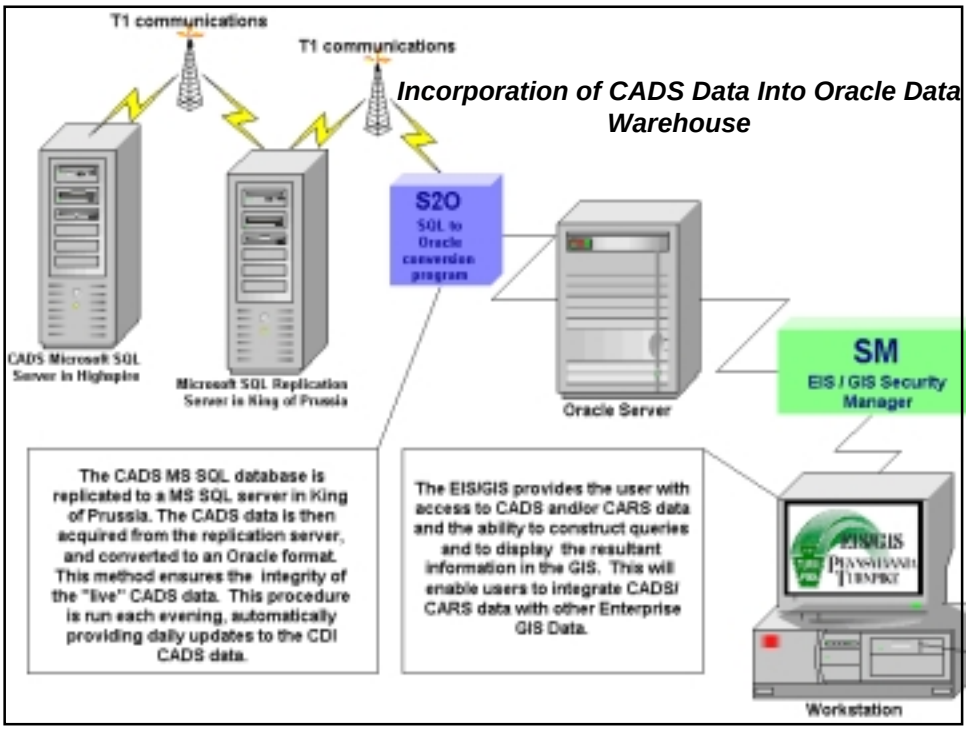
- *Integration of the Roadway Asset Management System - RAMS*

CADS

- *CADS- Computer Aided Dispatch System.*
- *Used by the Operations Center to handle the dispatching of response vehicles to incidents on the roadway.*
- *Kept on a separate server- located in Highspire operations center.*
- *Written in VB 6.0 using MapObjects in conjunction with a SQL 7.0 Database.*

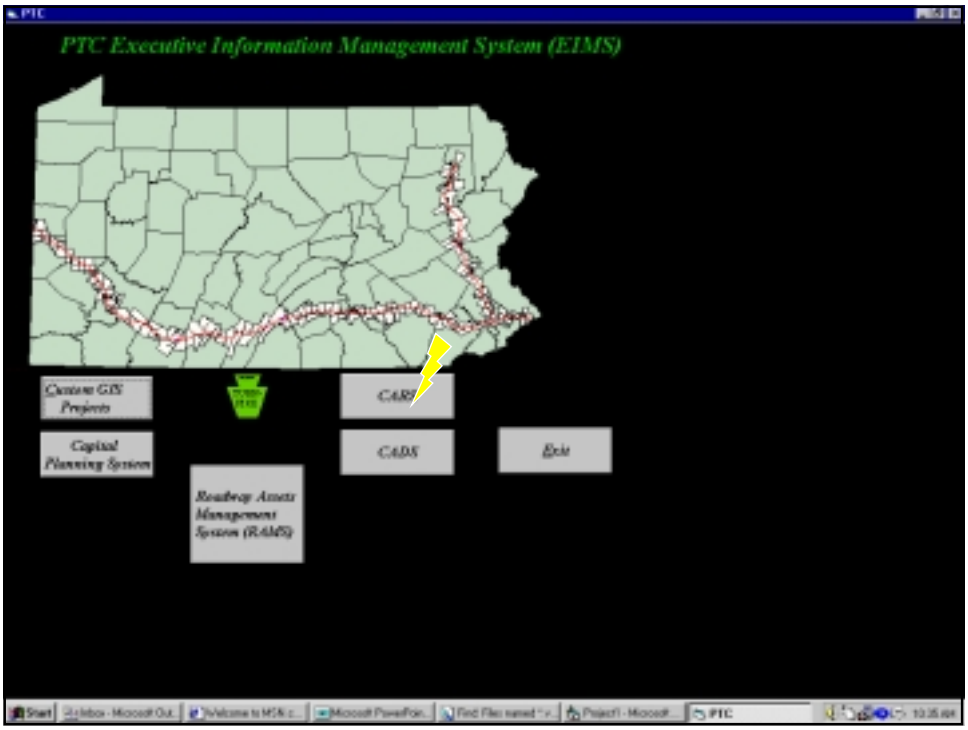



Active Resources
Resource Status
Available Resources

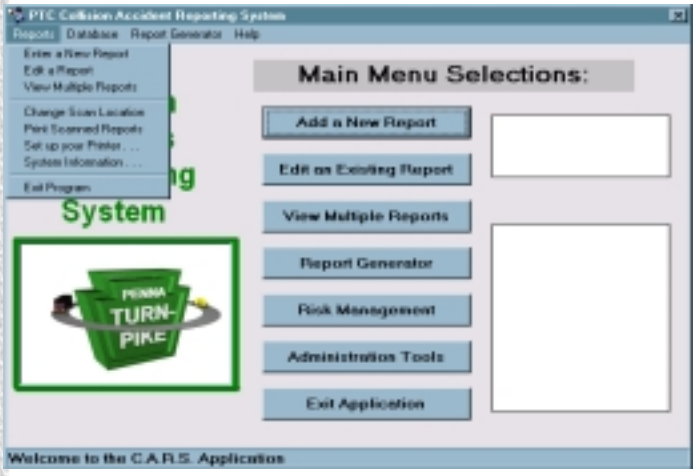

T1 communications
T1 communications
Incorporation of CADS Data Into Oracle Data Warehouse
S2O
SQL to Oracle conversion program
CADS Microsoft SQL Server in Highspire
Microsoft SQL Replication Server in King of Prussia
Oracle Server
SM
EIS / GIS Security Manager
The CADS MS SQL database is replicated to a MS SQL server in King of Prussia. The CADS data is then acquired from the replication server, and converted to an Oracle format. This method ensures the integrity of the "live" CADS data. This procedure is run each evening, automatically providing daily updates to the CDI CADS data.
The EIS/GIS provides the user with access to CADS and/or CARS data and the ability to construct queries and to display the resultant information in the GIS. This will enable users to integrate CADS/ CARS data with other Enterprise GIS Data.
Workstation

CARS Definition

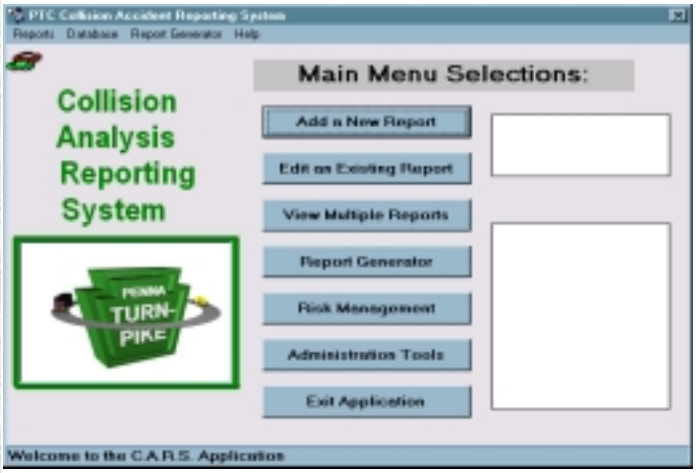
- *CARS- Collision Analysis Reporting System.*
- *Located on Central Office Network.*
- *Used by Risk Management to maintain PSP incident reports.*
- *Used by Engineering-Traffic for analysis and reporting.*



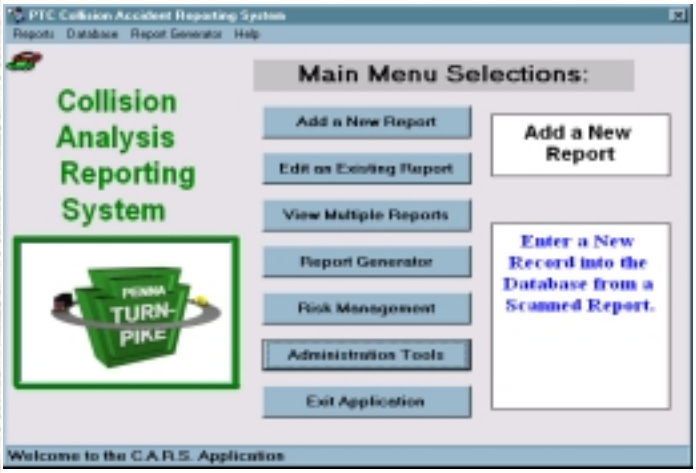
Splash Screen



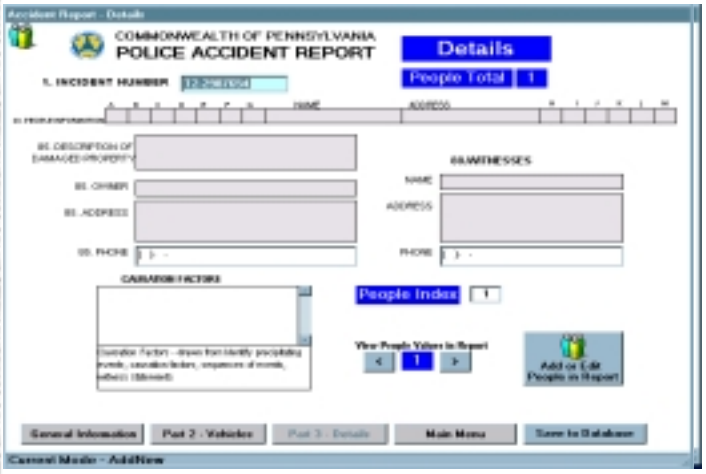
The Pull down menu choices.



"Mouse over" will display description, click to choose option.



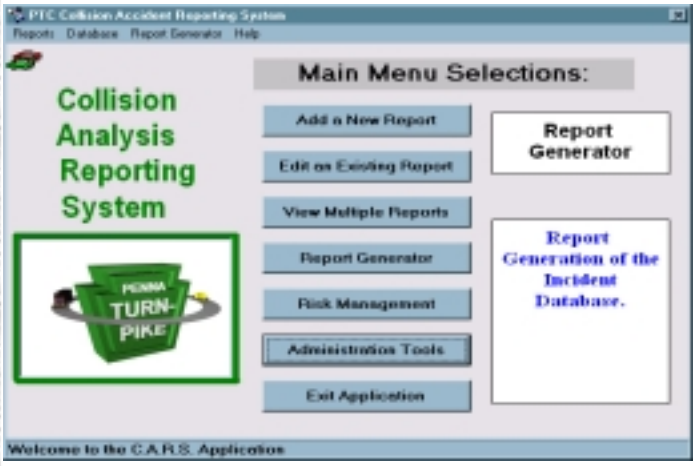
Click Add a New Report to enter new data.



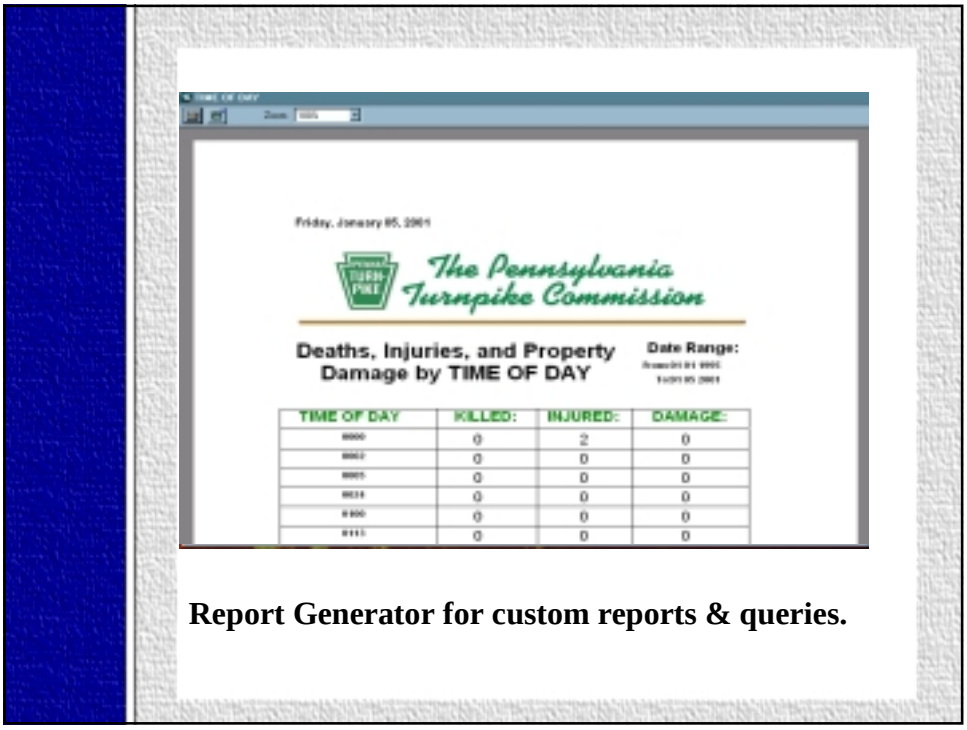
The PAR is divided into three parts: General Information, Vehicle Information, and Details.

Helper tables assist the user to input correct and consistent data.

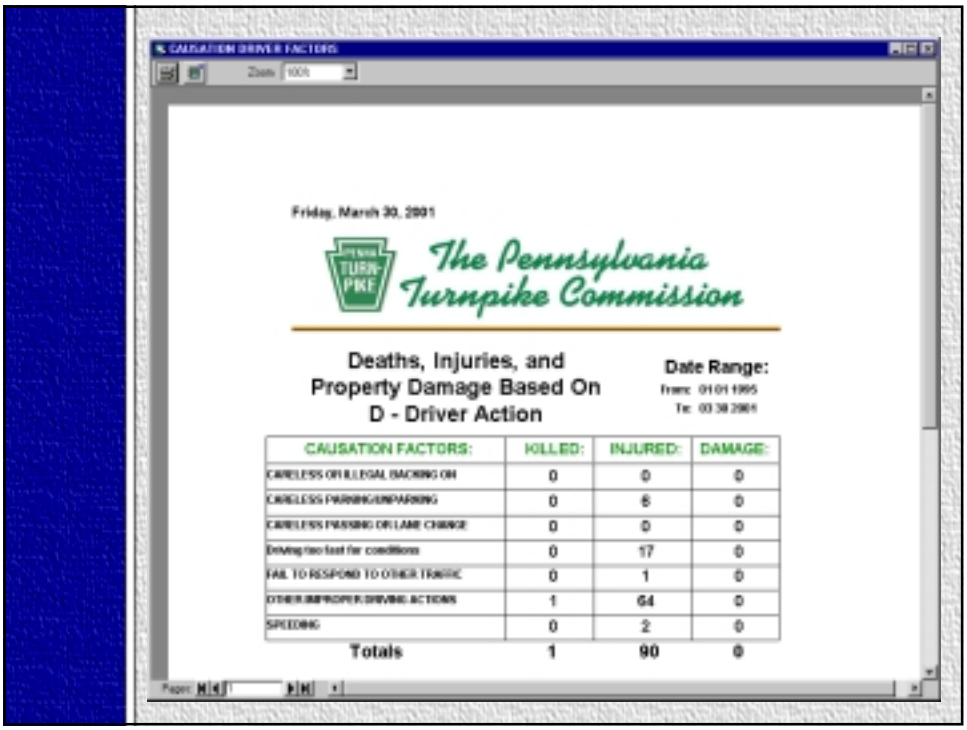
Clicking on Edit Existing Report allows modifications of data to be made.



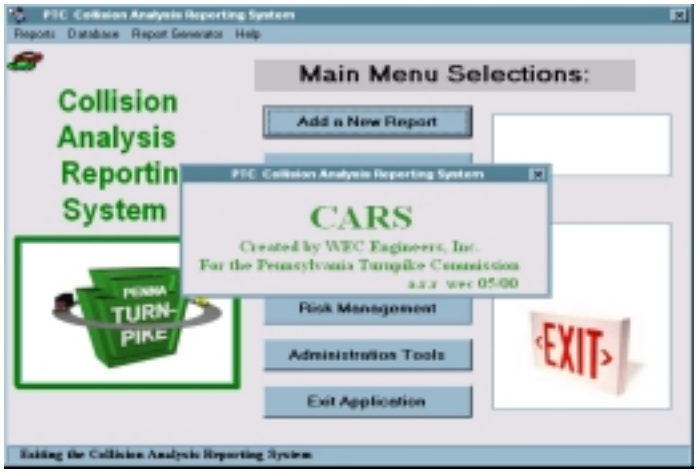
Report Generator for custom reports & queries.



Report Generator for custom reports & queries.

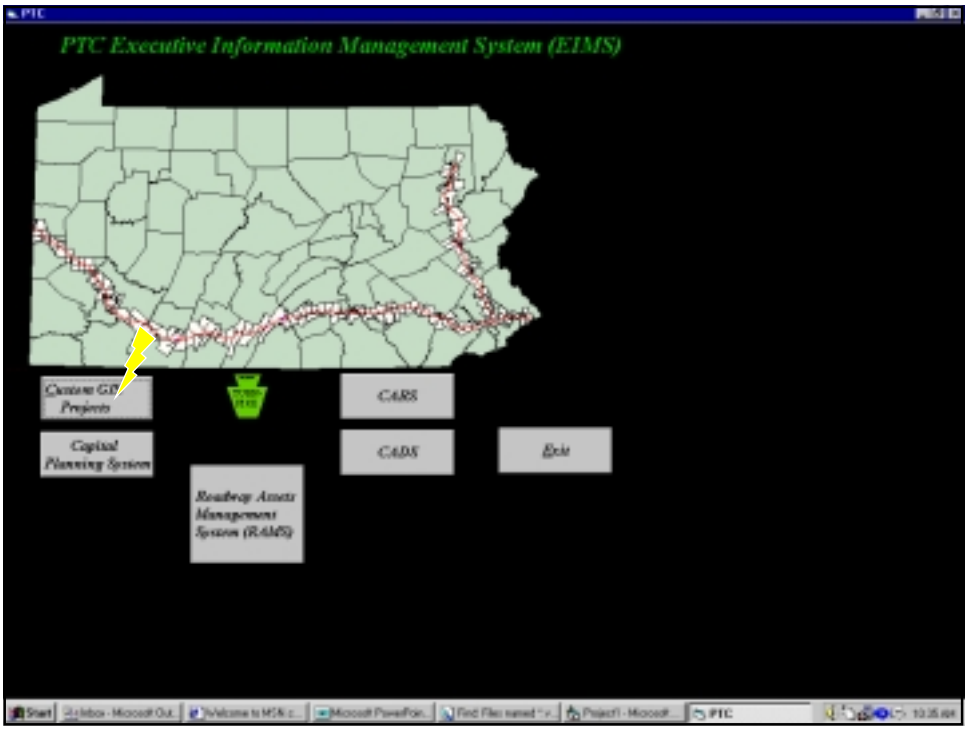


Exiting Program

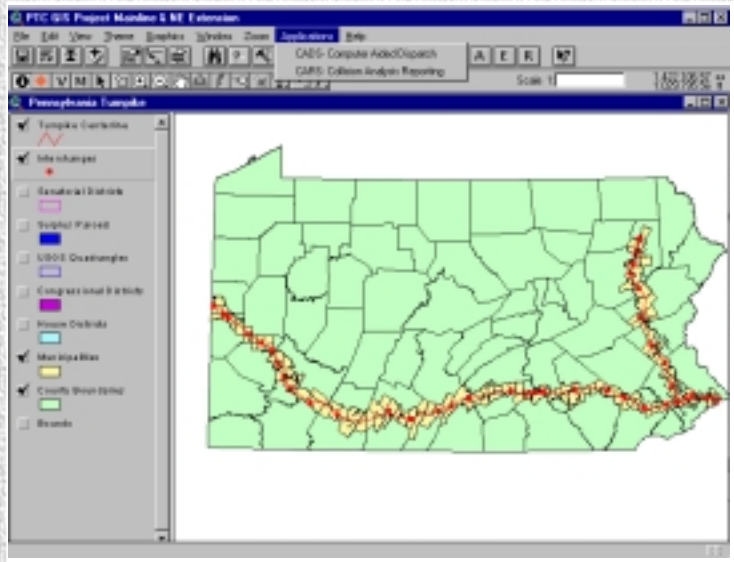


Integration Objectives

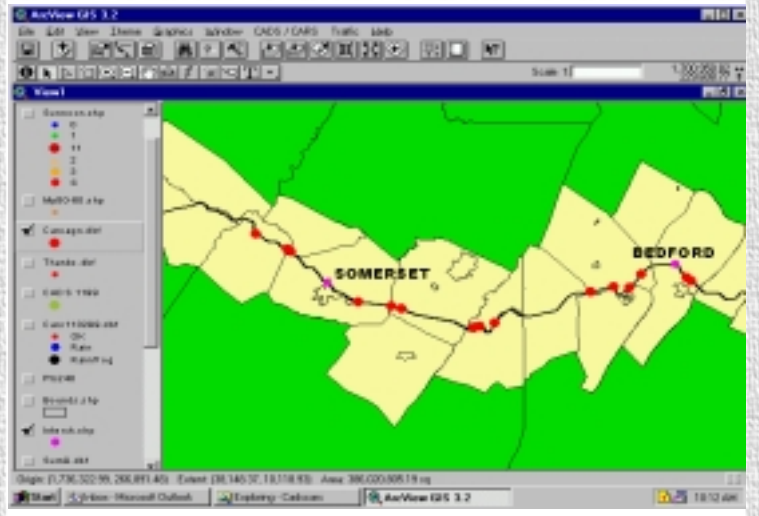
- *Geographically Enable the CARS Database;*
- *Incorporate the CADS Database into the Oracle Warehouse;*
- *Enhance the Analysis Capabilities of Design and Traffic Engineering Personnel; and*
- *Provide Key Staff with a new and Powerful Decision Support Tool*


PTC Executive Information Management System (EIMS)
Custom GIS Projects
CARS
Capital Planning System
CADS
Exit
Roadway Assets Management System (RAMS)

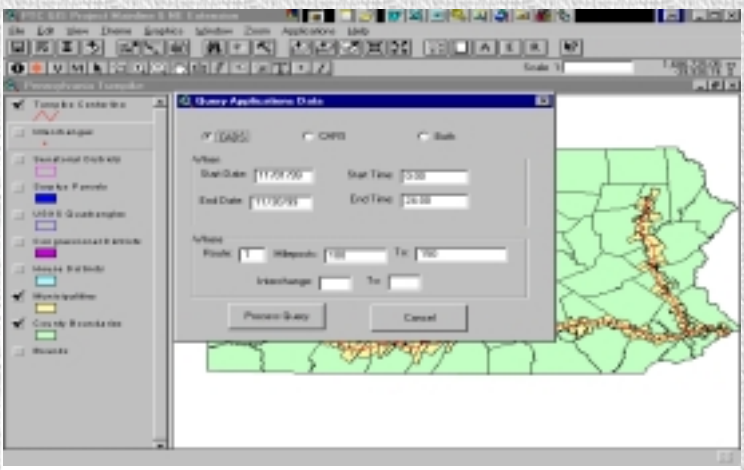

Pennsylvania Turnpike Commission
PA TURNPIKE
Beaver Valley
A.K. Hutchinson
Mon-Fayette
Mainline and NE
Overview
Exit Application
EXIT
GIS Applications



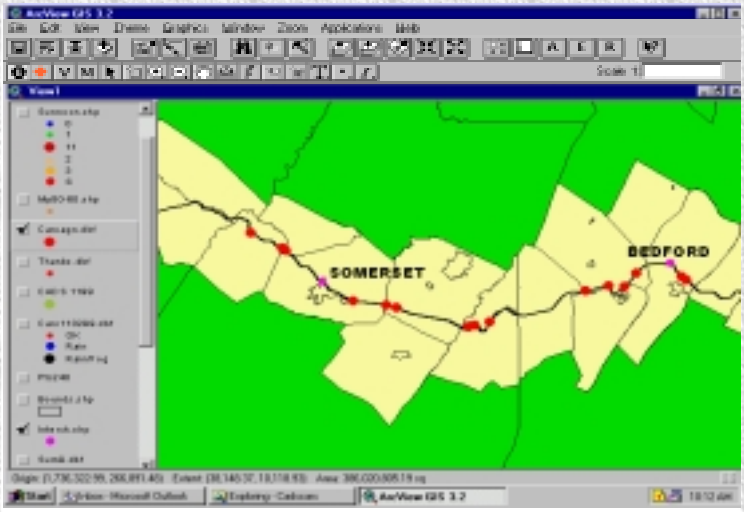
From the Applications Menu at the top of the GIS project users have the ability to query existing data from CADS and/or CARS.



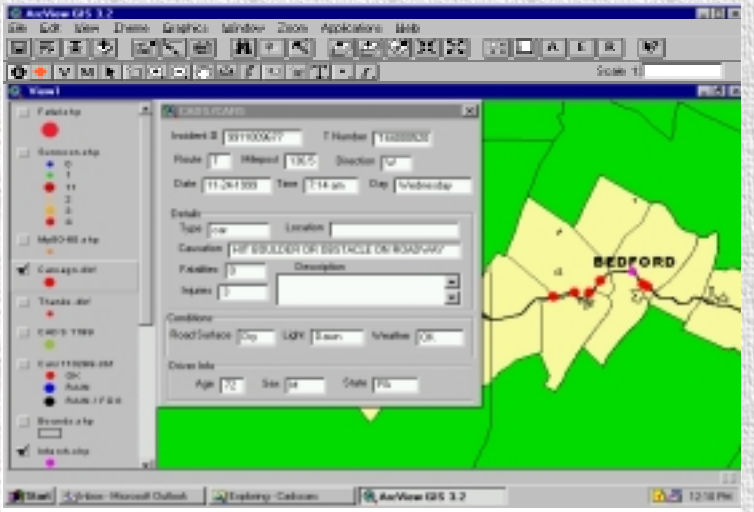
From the Menu CADS/CARS at the top of the GIS project users have the ability to query existing CADS/CARS data.



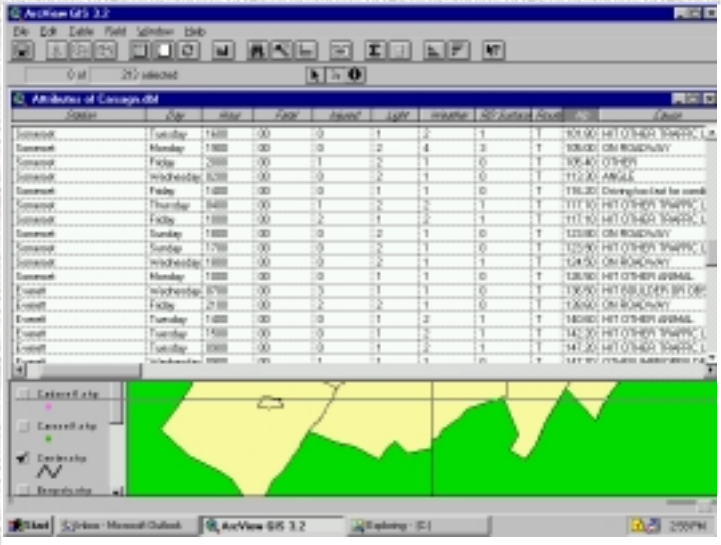
Users are first given the option of extracting CADS and/or CARS data for a selected date range and/or segment of a facility specified either by Route and Milepost Range or beginning and ending Interchange. Here, a months worth of CADS incidents that occurred between mileposts 100 and 150 on the Mainline are requested.



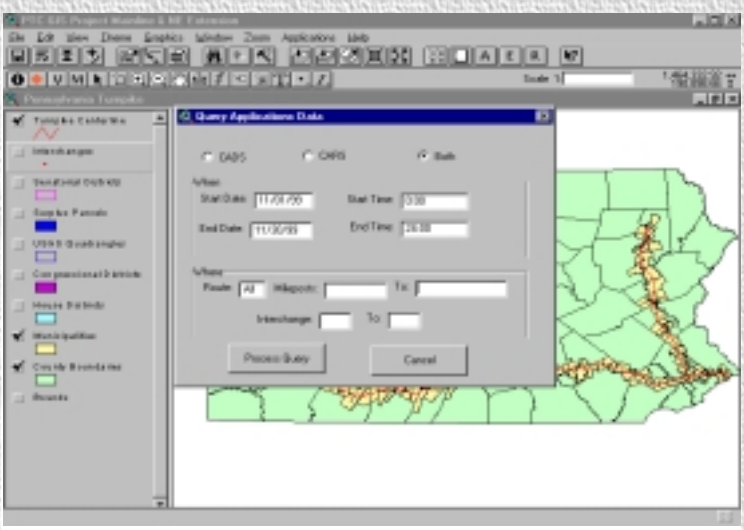
The CADS database is then automatically queried, an ArcView theme constructed from the results, and the view automatically zooms to the extents of the selected features.



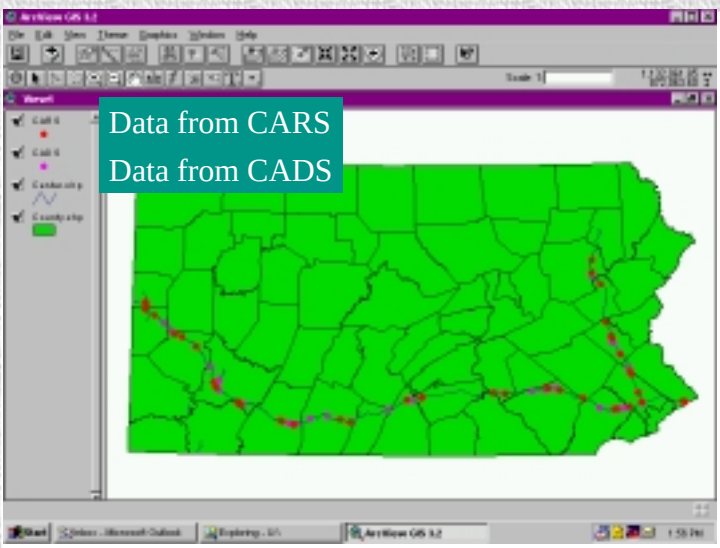
Information regarding any selected incident can be accessed by simply clicking on it on the map.



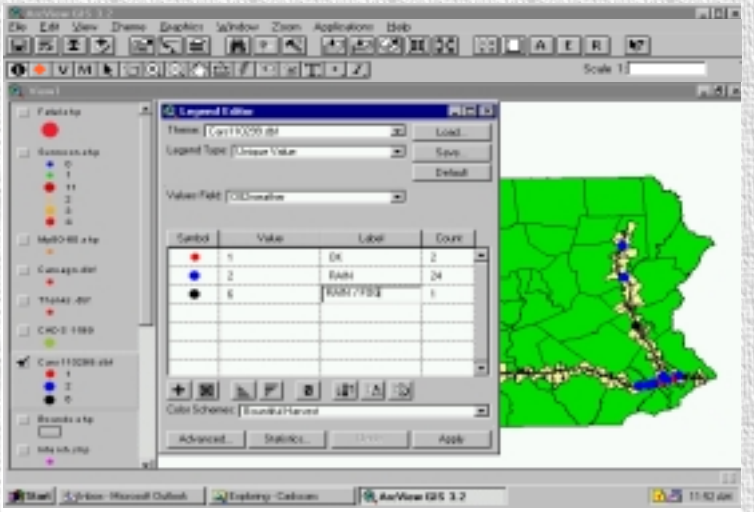
Multiple records can be viewed simultaneously by opening the Table View for the selected set.



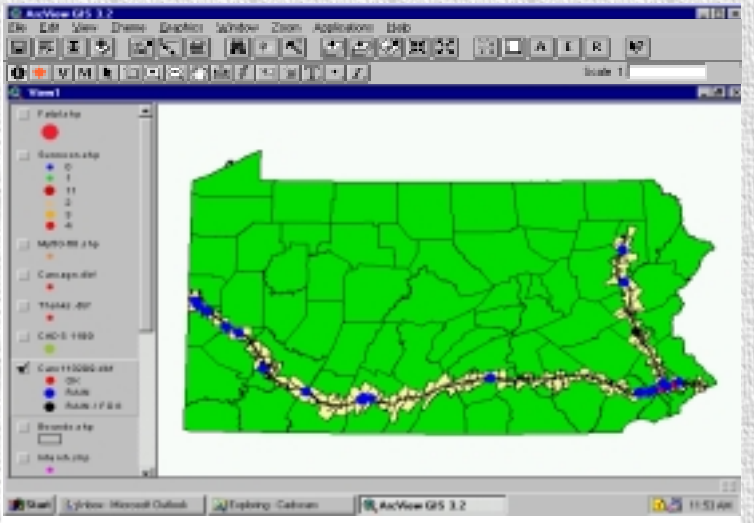
In this example, the user requests all available data from both the CARS and CADS databases for a month (Nov) for all routes.



The database is automatically queried and the results are converted to an ArcView theme and displayed. The view extents are unchanged because we asked for all routes.

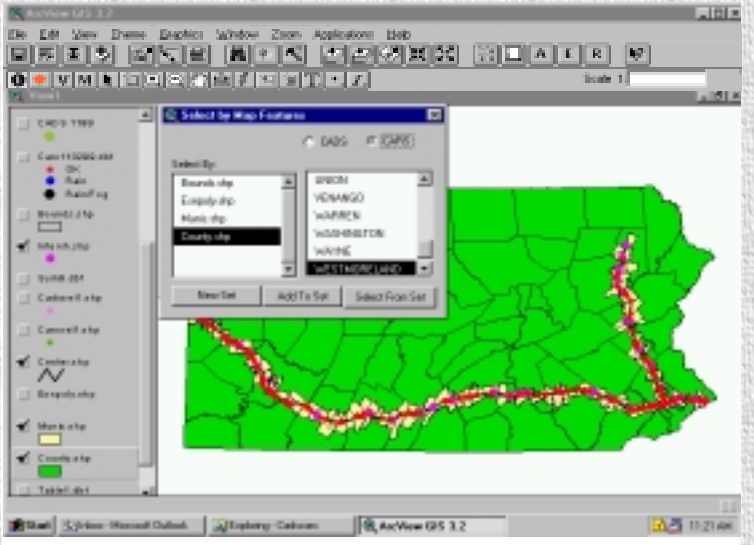


The data can be classified according to values in any field. In this example, CARS accident data are categorized by weather condition.

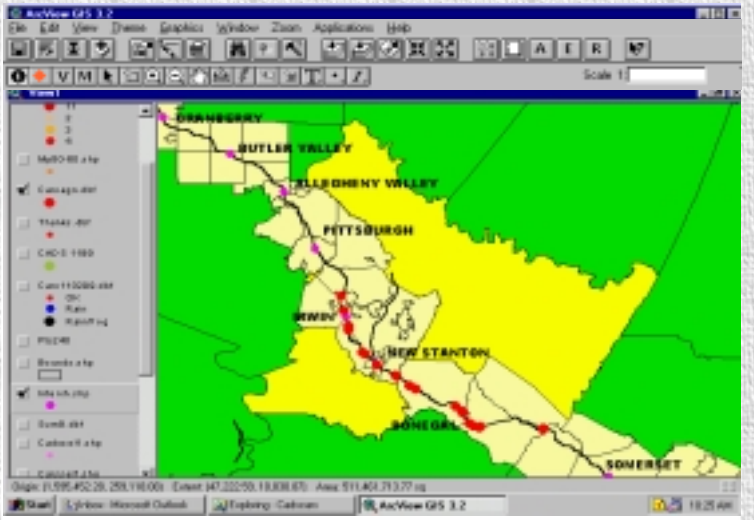


CARS data are then displayed and color-coded according to those weather conditions.

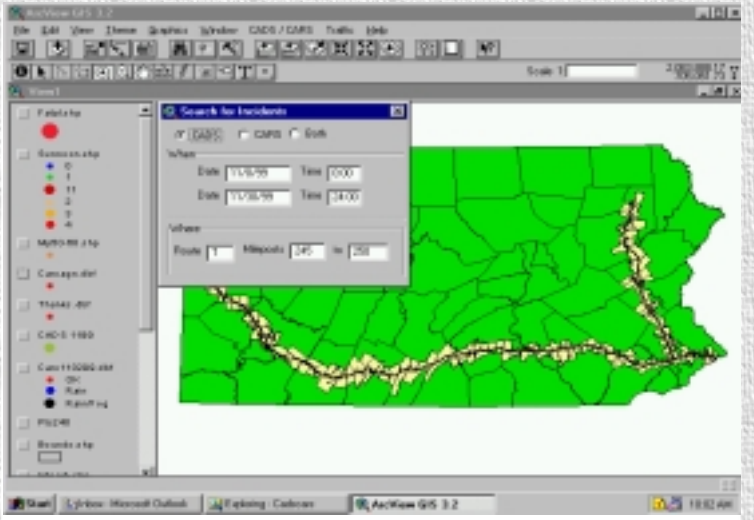
An ArcView Layout Document can be created to allow custom maps and reports to be printed.



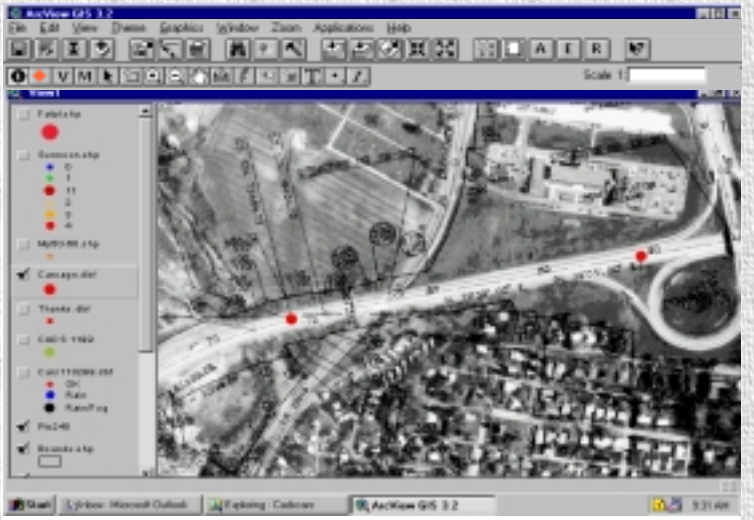
Spatial queries can easily be made. Here the user is finding all CARS data for Westmoreland County.



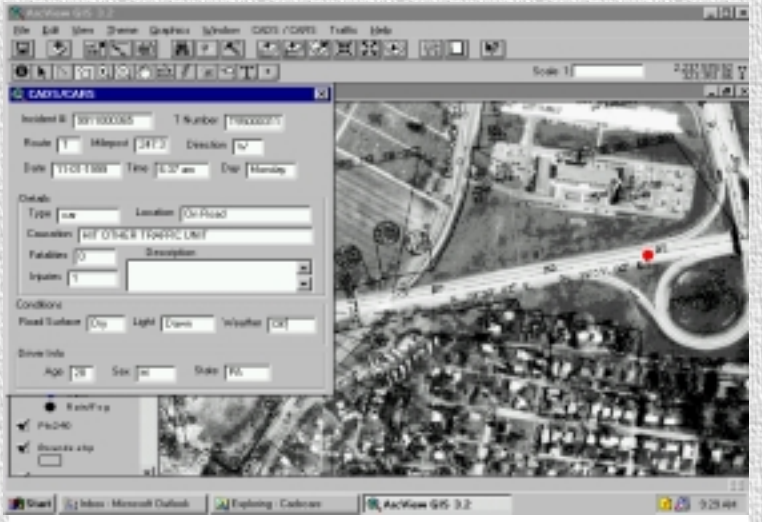
All of the records for Westmoreland County are selected and the view is automatically centered on and zoomed to the selected features.



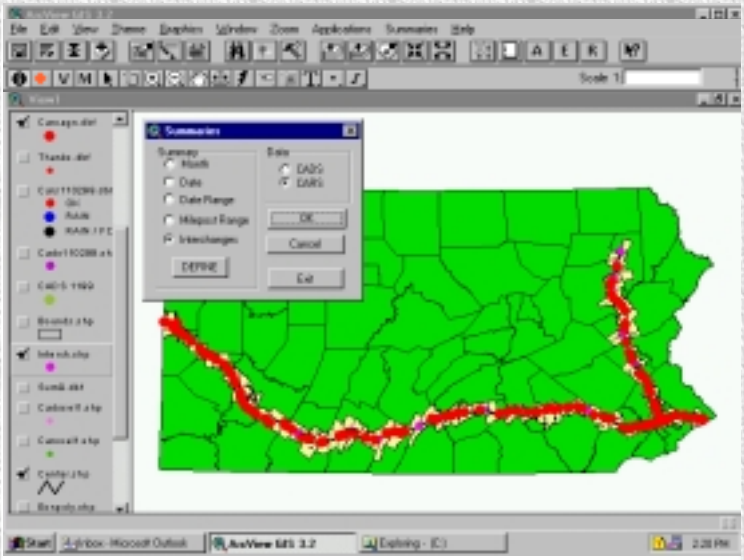
Any segment of the roadway can be focused on. In this example, all incidents for November 1999 that were reported between mileposts 245 and 250 are requested.



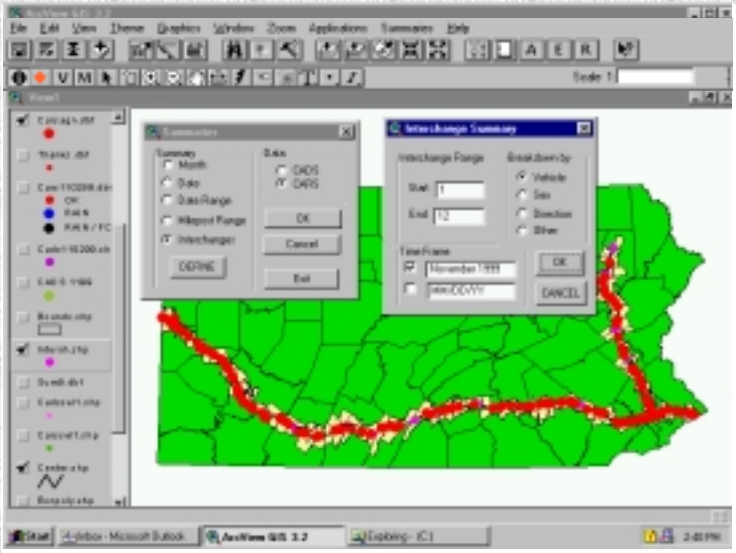
This example demonstrates how the data can be plotted onto the Mosaics.



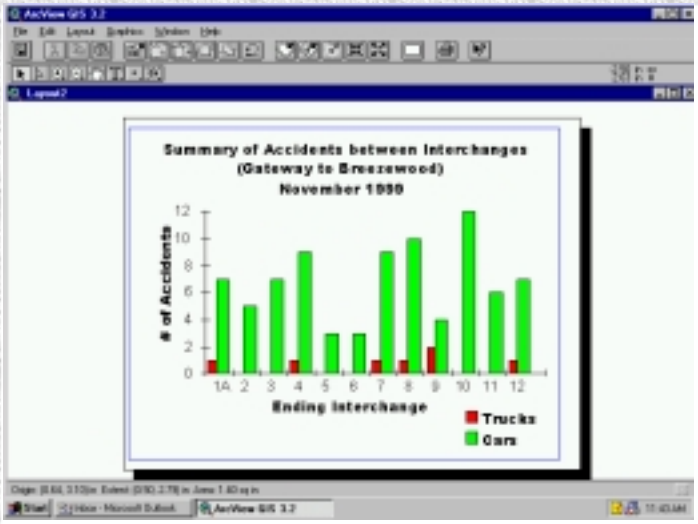
Information regarding an individual incident can be accessed by simply clicking on the screen.



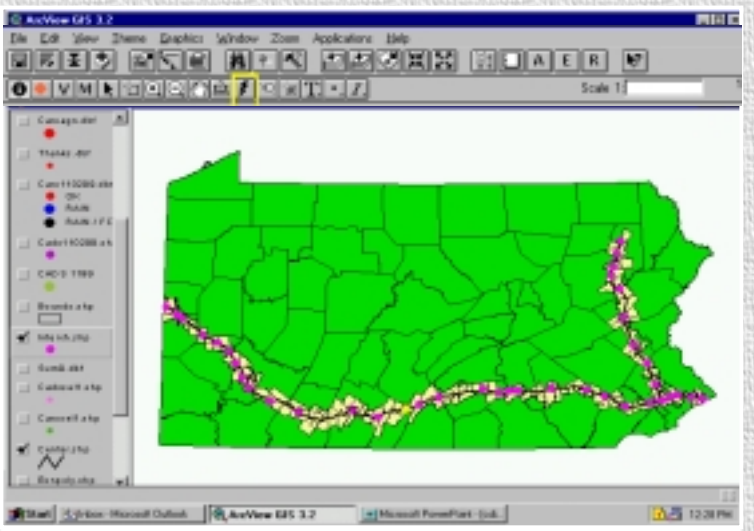
Users are able to summarize data by a number of factors. In this example, CARS data will be summarized by Interchange range.



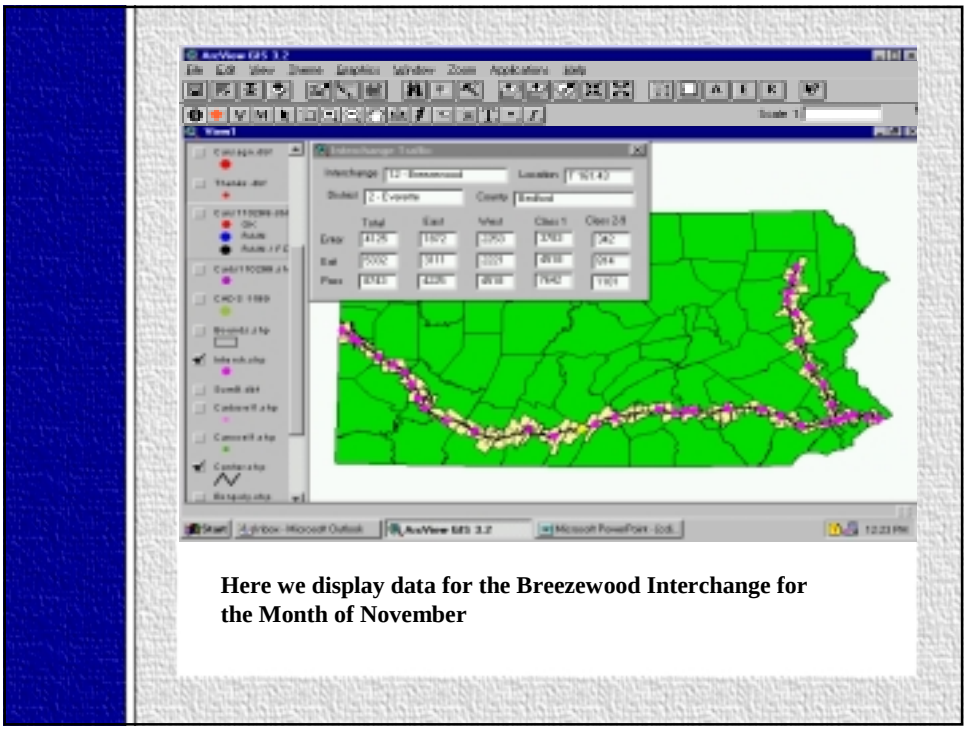
The user chooses the Interchange, Date and Data to be summarized.



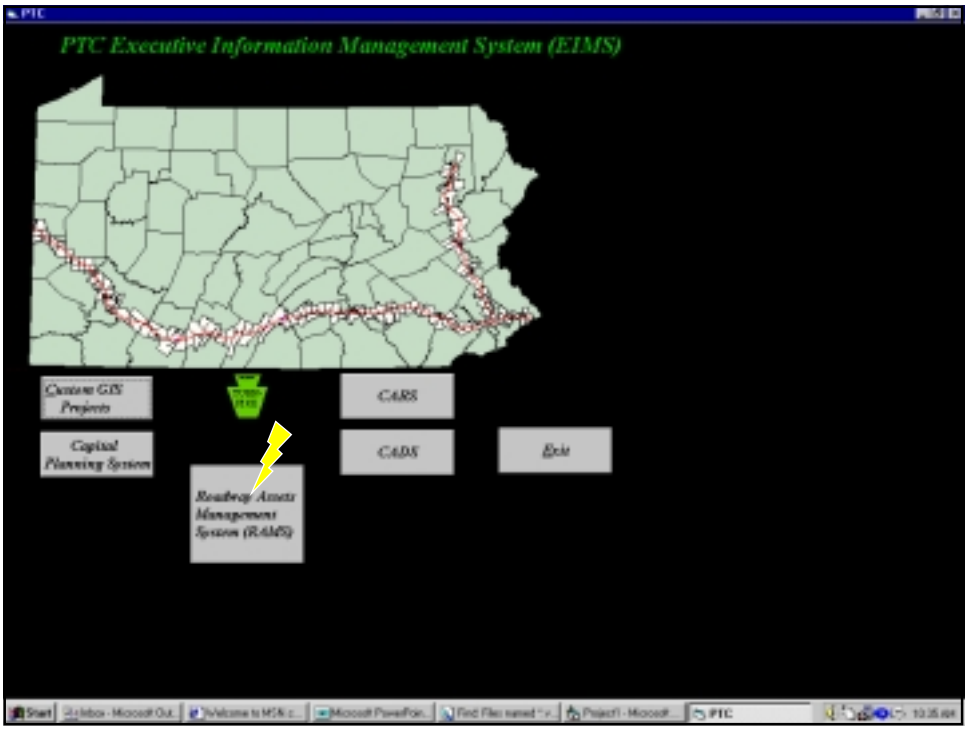
A chart showing the frequency of accidents (by vehicle type) between interchanges is prepared and displayed.

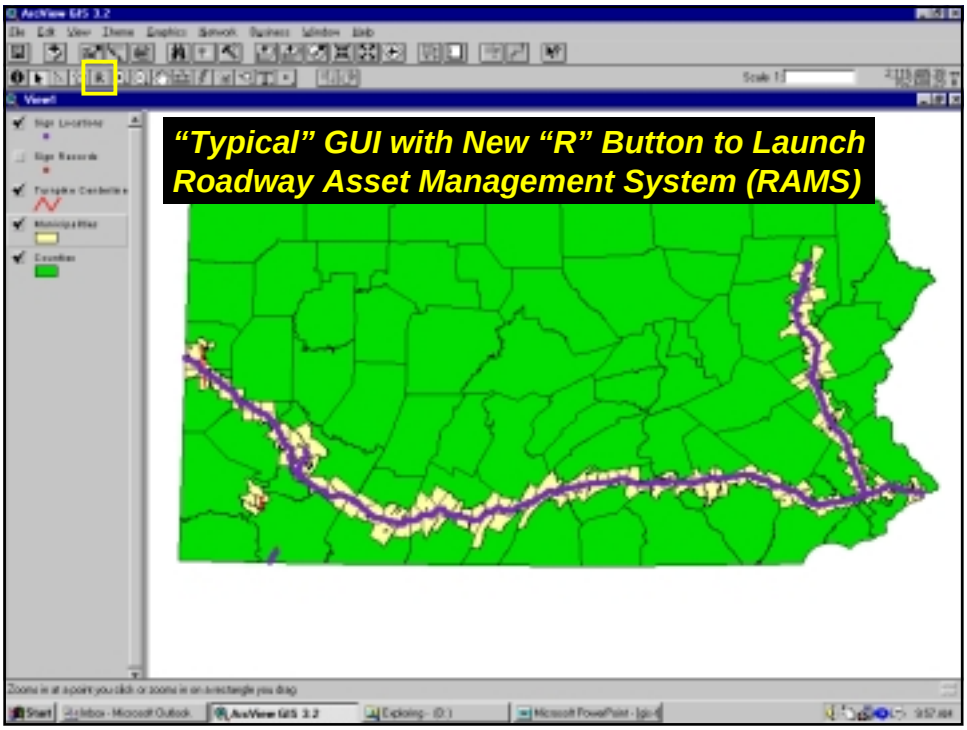


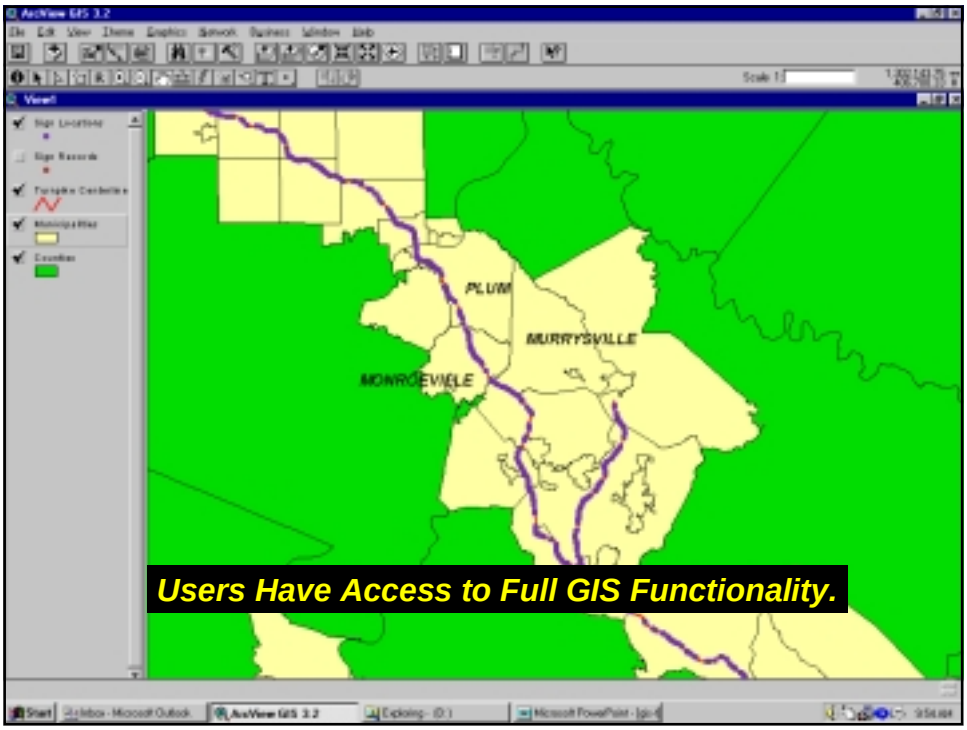
By making the Interchanges theme the active theme, Selecting the "Hotlink" tool and clicking on an Interchange we can provide access to traffic statistics for the time period we are analyzing.

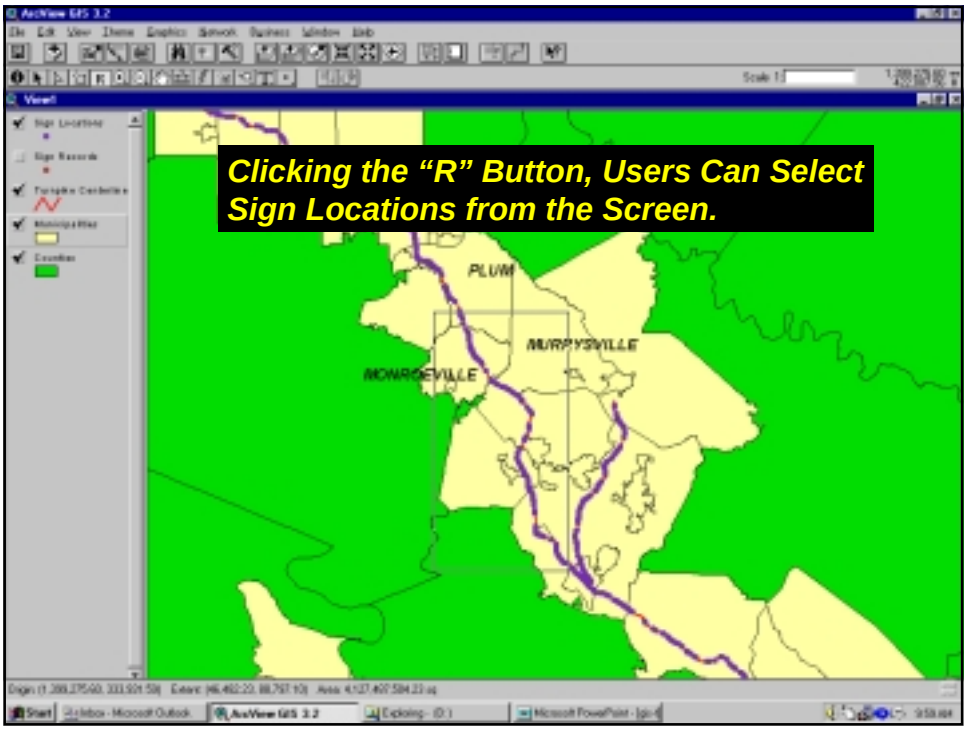


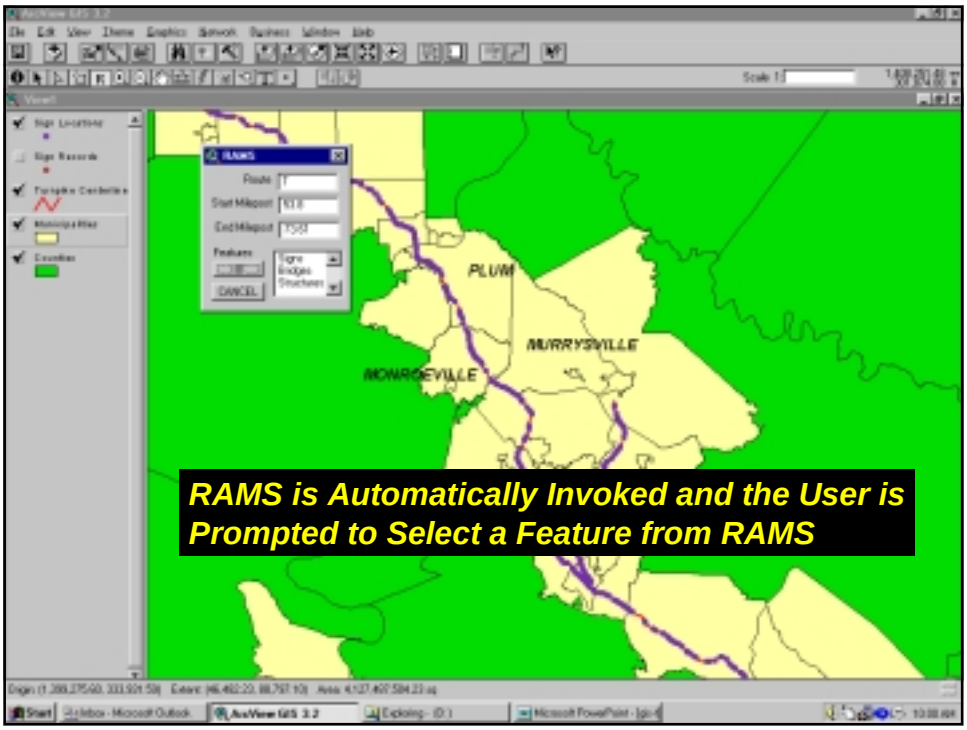
Here we display data for the Breezewood Interchange for the Month of November

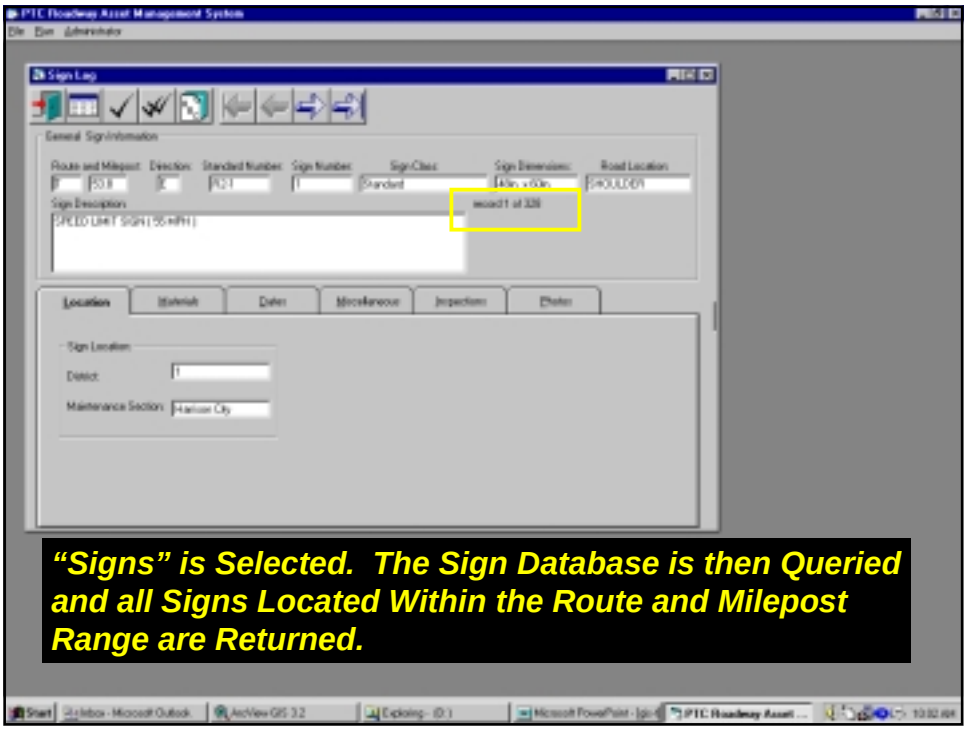



"Typical" GUI with New "R" Button to Launch
Roadway Asset Management System (RAMS)

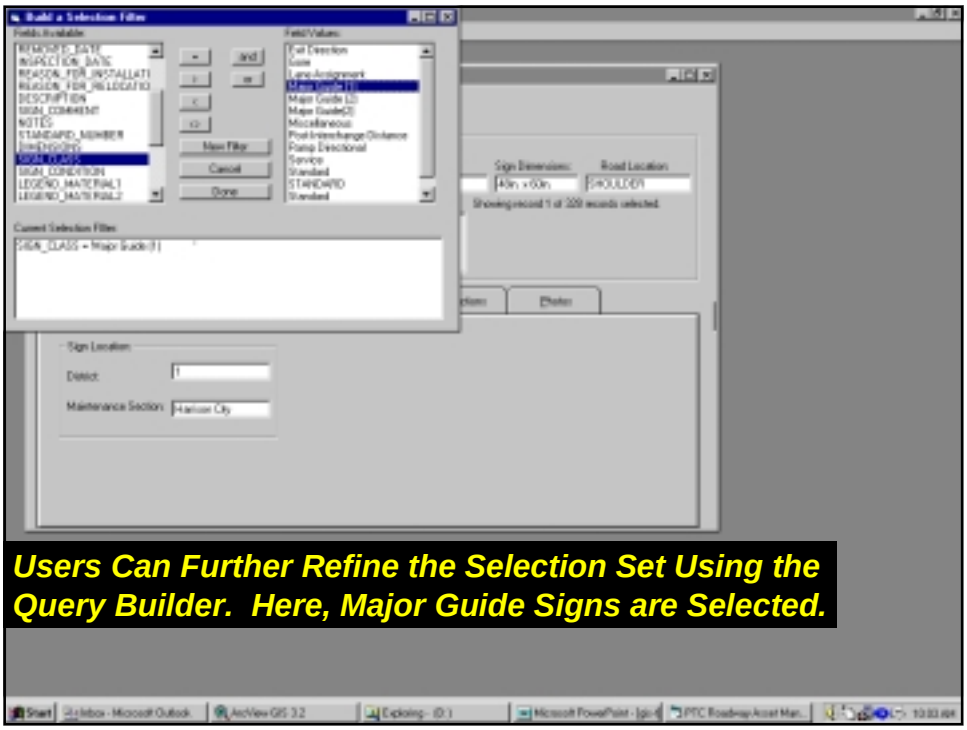

PLUM
MURRYSVILLE
MONROEVILLE
Users Have Access to Full GIS Functionality.


Clicking the “R” Button, Users Can Select Sign Locations from the Screen.
PLUM
MURRYSVILLE
MONROEVILLE

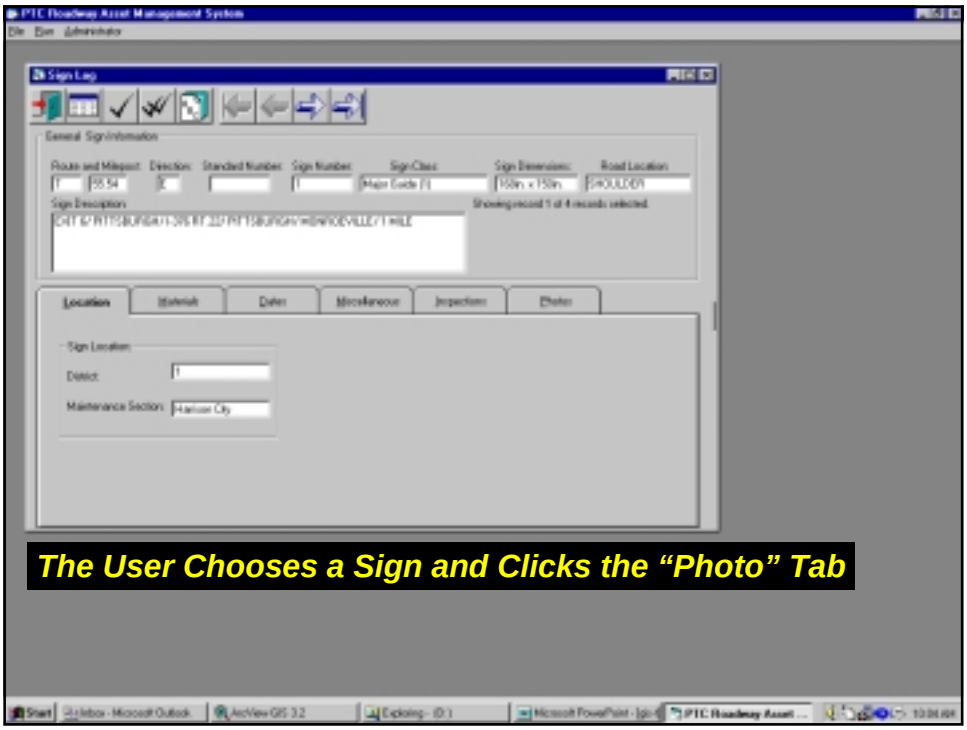

RAMS is Automatically Invoked and the User is Prompted to Select a Feature from RAMS
PLUM
MURRYSVILLE
MONROEVILLE

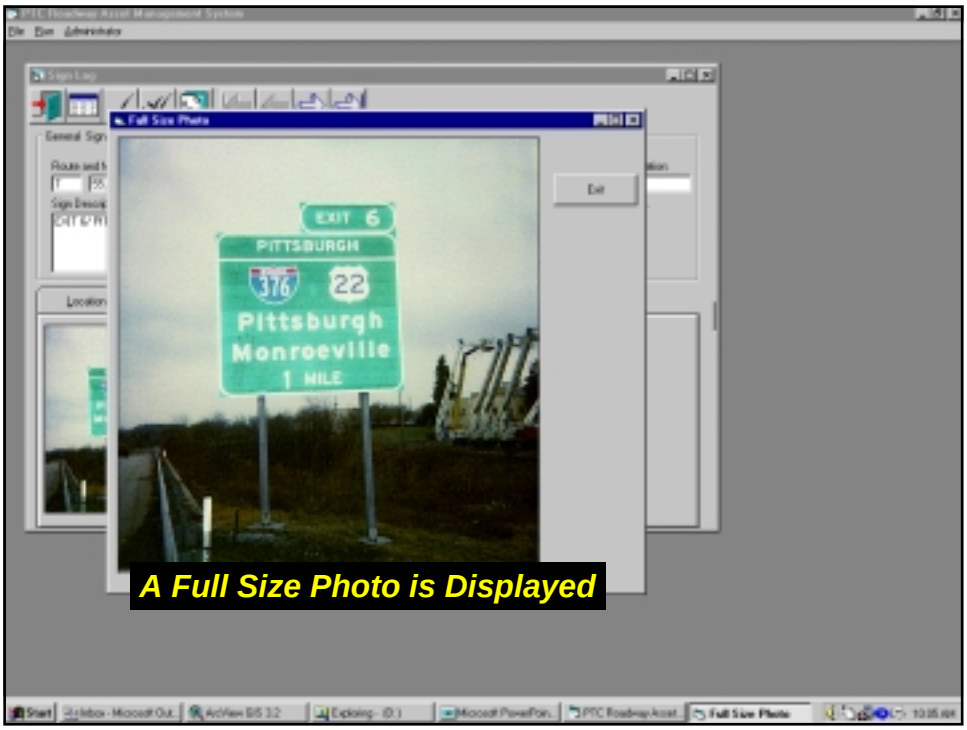


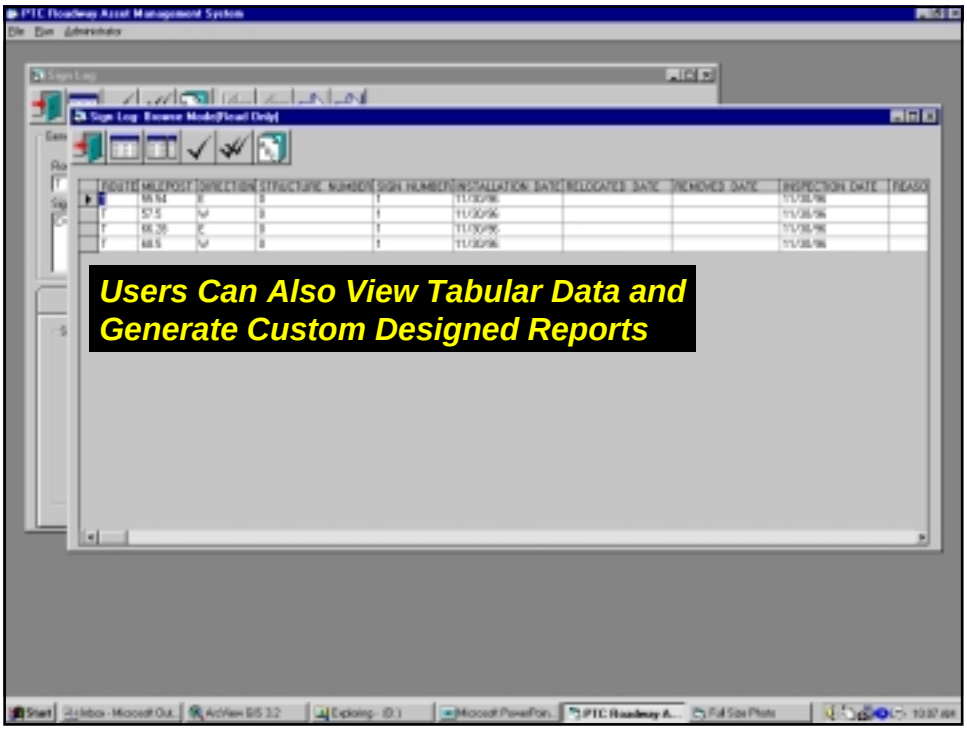
"Signs" is Selected. The Sign Database is then Queried and all Signs Located Within the Route and Milepost Range are Returned.



Users Can Further Refine the Selection Set Using the Query Builder. Here, Major Guide Signs are Selected.


The User Chooses a Sign and Clicks the “Photo” Tab

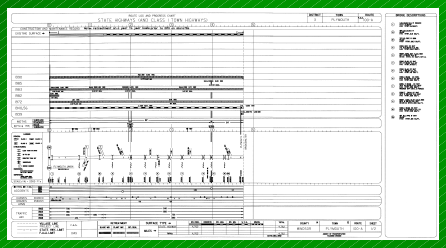

EXIT 6
PITTSBURGH
376
22
Pittsburgh
Monroeville
1 MILE
A Full Size Photo is Displayed



Future Activities

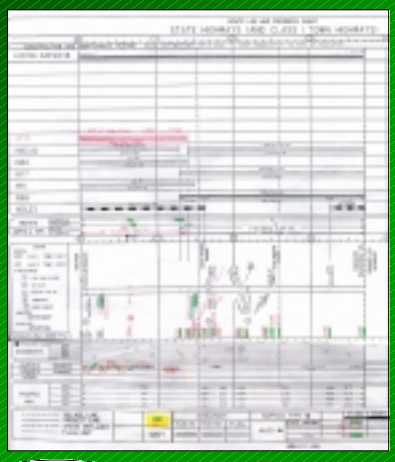
- *Expansion of RAMS and Subsequent Inclusion in EIS/GIS;*
- *Integration of Document Management System;*
- *Web Enabling EIS/GIS*

The Digital Age and the Route Logs



- Early 1980's: CADD Route Logs developed with Intergraph software
- Custom application developed internally to generate the straight-line diagrams
- System used and maintained until 1992; 1/2 the logs converted from hand-drawn to CADD

Current Situation at VTrans



- Intergraph Route Log application is defunct
- No ability to easily update CADD route logs
- Only a master set of logs is being updated with key information, by hand
- We're in a holding pattern; the Route Logs are on life support.

What's Next???

"We Need Up-To-Date Route Logs!"

The Mandate

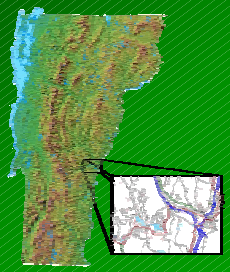
- VTrans will produce a new series of Route Logs for all the State and Federal Aid Routes within Vermont

The Question

- How do we proceed & can we incorporate GIS???

Steps Toward GIS Implementation

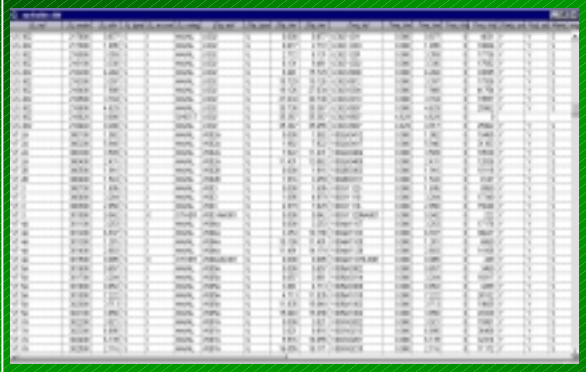
GIS



U302-0912
S56000405
V100-1421

- VTrans has in place a GIS infrastructure
- ArcInfo-based Road Centerline data for all 14,000 miles of public highway
- All 3,893 miles of Federal Aid System are mapped with linear reference codes

Master Route Definition Table



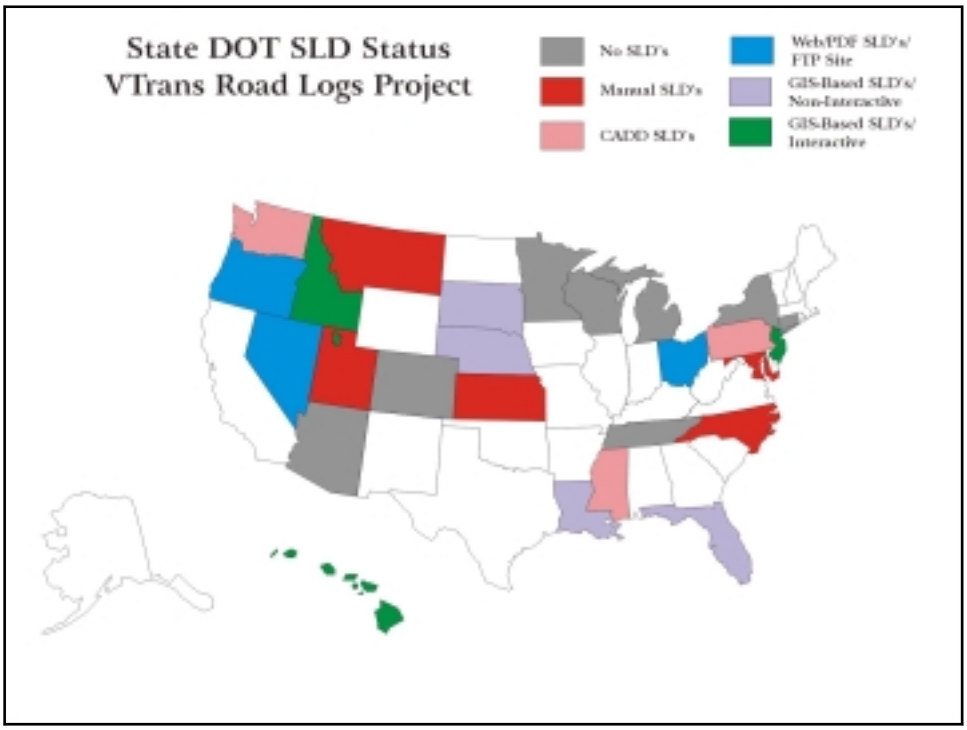
- Each State and Federal Aid Route (1,170 routes) documented
- Standardized linear reference coding with measures in end-to-end and town-based systems

The Digital Route System

- With assistance from VCGI, an ArcInfo Route System generated combining RDS data layer and MRD Table
- VTrans and VCGI develop data layers based on linearly referenced databases, including AADT, Accidents, HPMS, Structures, Pavement Conditions, Sufficiencies, and Utility Permits

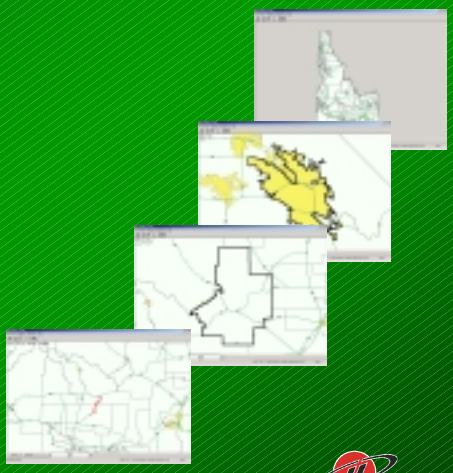
Steps Toward a New Route Log System

1. Survey of the VTrans Directors, Section Chiefs and key users
2. Preliminary needs assessment
3. Inventory of existing databases to support a Route Log system
4. VTrans contracts with Geo Decisions to do a survey of DOT's and assess straight line diagram software

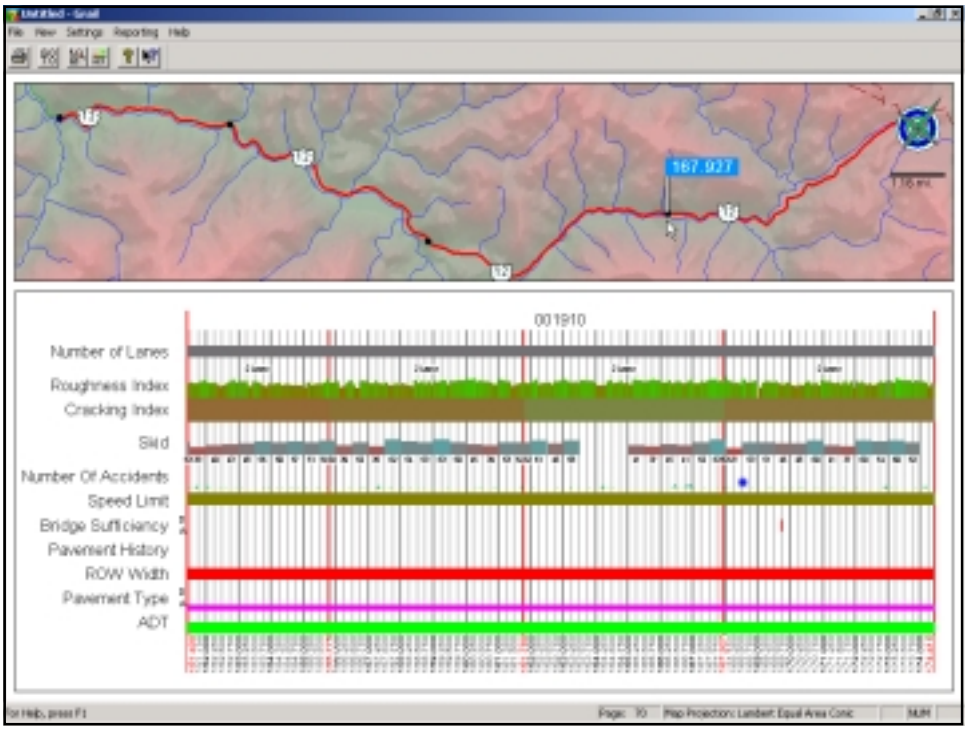


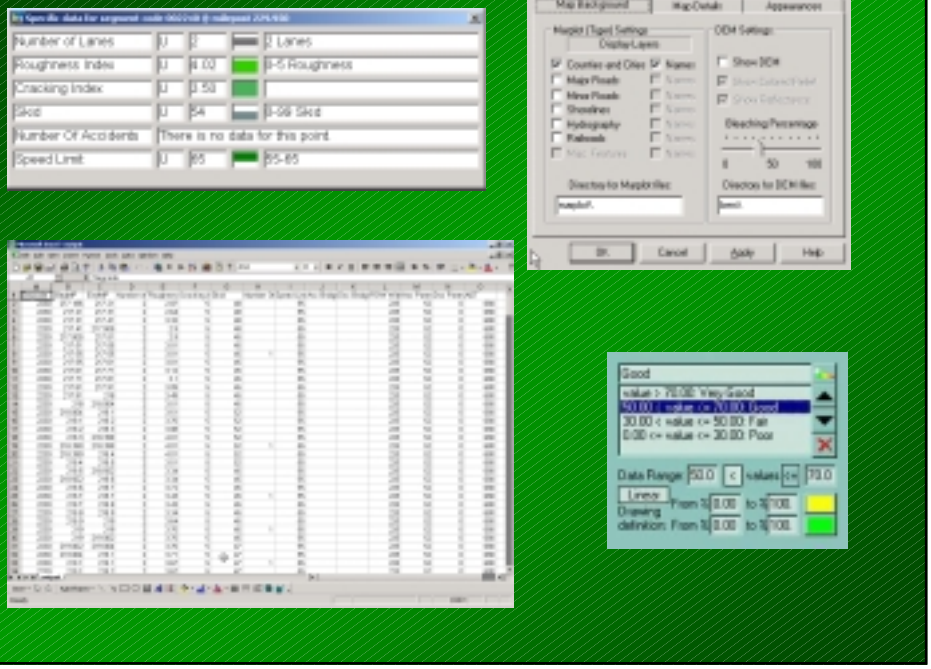
Relevant State DOT Examples

- Idaho “GRAIL”



VTrans Route Log Assessment





Idaho "GRAIL"

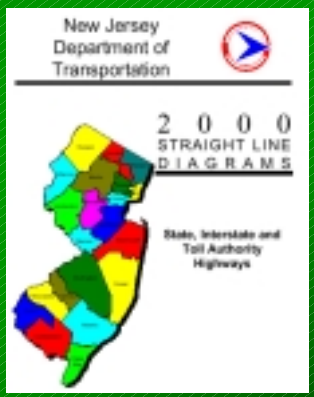
- In-house
- Milepost based
- Visual C++
- 3-4 years old
- Uses database extracts (ASCII)
- No direct data connection
- CD-enabled
- 2-year development time: 1.5 people
- Current data only

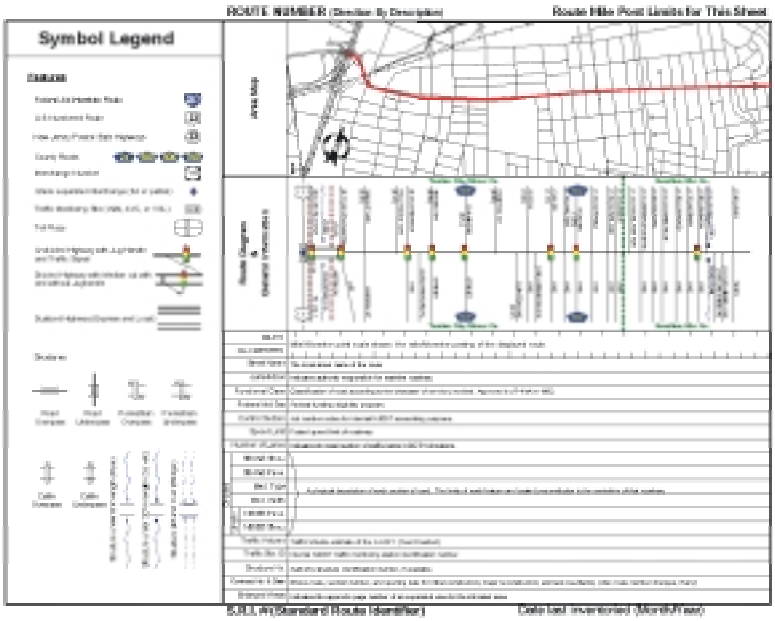
Idaho “GRAIL”: Future Plans

- Direct RDBMS access
- Historical data
- Videologs (beta completed)
- Make easier to use
- Reduce user-specific configuration problems

Relevant State DOT Examples

- New Jersey
  - Web PDF enabled
  - Visio +Visual Basic





New Jersey SLD's

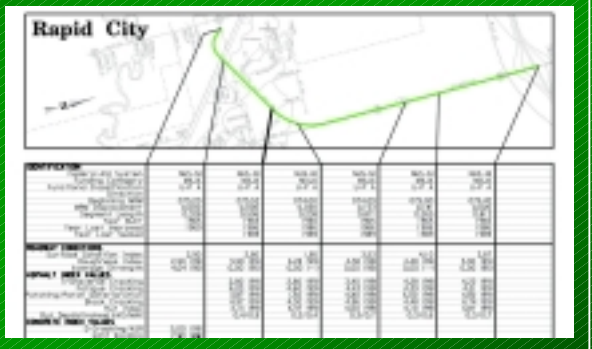
- Consultant-developed
- FHWA sponsorship
- Intergraph-based road graphics
- 4 years old
- Data accessed from SQL Server 7
- No interactive map
- Distributed on-line, via CD
- Substantial $ developmental cost
- Videolog links

New Jersey SLD's: Future Plans

- Upgraded GIS capabilities
- GPS-based road graphics
- More miles of roadways

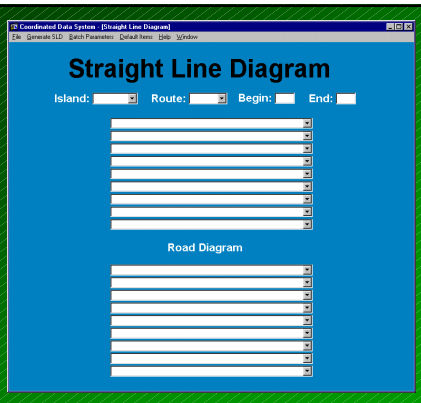
Relevant State DOT Examples

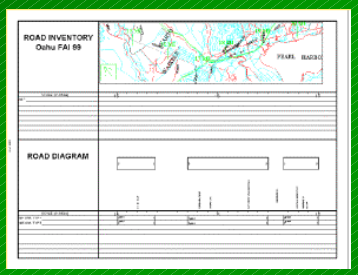
- South Dakota
  - C++
  - PDF format

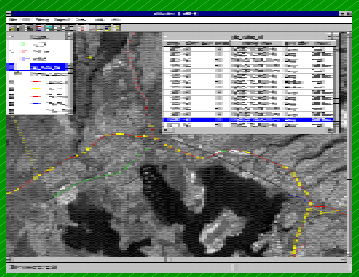


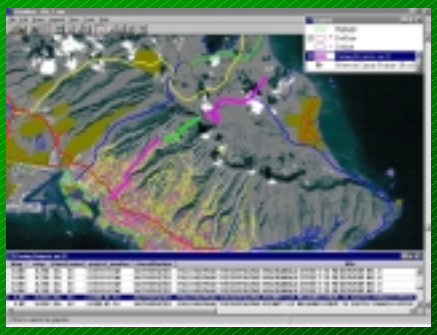
Relevant State DOT Examples

- Hawaii
  - Intergraph-based
  - Phase I older technology
  - Phase II updated tools









State DOT Research Report

- NCHRP Report 437: Collection and Presentation of Roadway Inventory Data
  - Evaluation of 4 DOT SLD practices
  - Evaluation of Bentley GeoDynSeg product
- Major Conclusions:
  - All automated methods used developed in-house
  - GeoDynSeg has substantial learning curve in setup

State DOT Review Results

- Very few states advanced in GIS-SLD
- Database access immaturity
- No widespread off-the-shelf software
- Definite need exists

VTrans Future Development

- Review of requirements
- Evaluation of products
- Recommended approach
- Conceptual design and issues

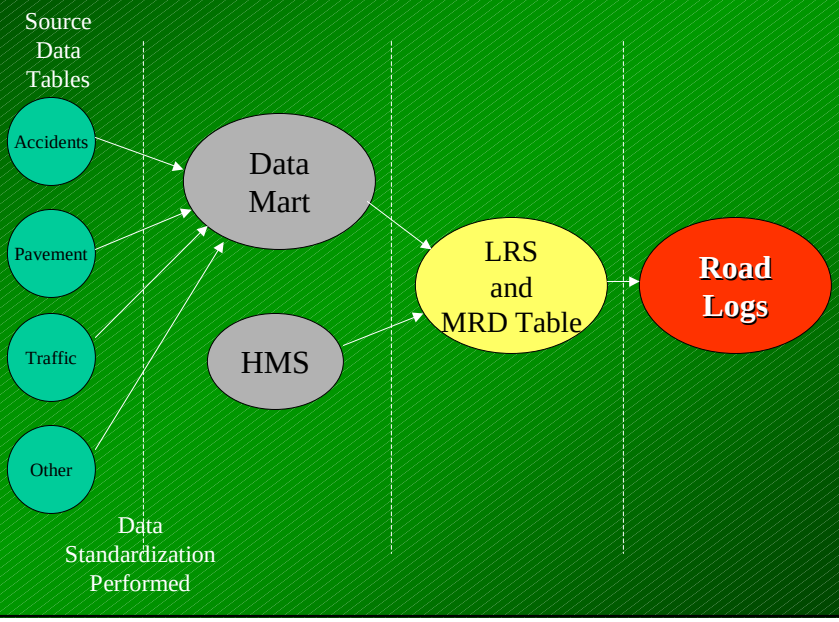
Required System Specifications

- ArcInfo Route formats supported
- Use ArcSDE and GeoDatabases
- Support linear referencing, digital images
- Use SQL Server database
  - Oracle, Access databases through ODBC
- Custom programming with Visual Basic

Functional System Specifications

- Phased approach
  - High Priority
    - What is available now
  - Medium Priority
  - Low Priority
- Add data as it becomes accessible
- Add desired features as program success builds

VTrans Road Logs Conceptual Data Model



Evaluation of Software

- No existing products meet enough specifications
  - Don't work with ESRI data formats
  - Costly software
  - Not interactive
  - Poor upgrade path for ESRI's future

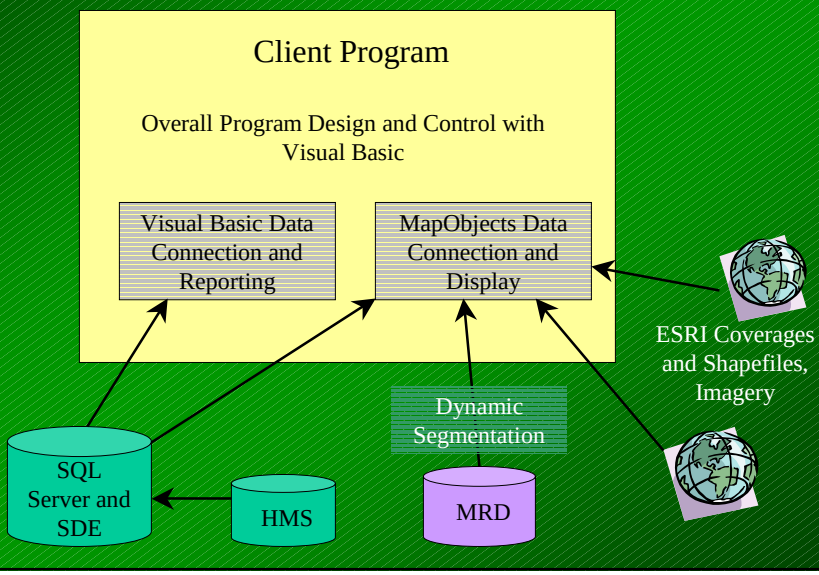
Recommended Approach

- Idaho, New Jersey, and Hawaii built successful programs
- Visual Basic and MapObjects should be used to build a solution
- Migrate pieces to the Web over time (ArcIMS and SDE)

Conceptual Design

- Client program in client-server environment
  - Web tools not mature yet
- Component Object Model compliance
  - Integration with ArcGIS
- Meet baseline, high priority needs and functions

Conceptual Design



Design Issues

- LRS synchronization
  - GIS, attribute LRS elements must be managed, in sync
- Migration to ArcIMS when appropriate
  - Visual Basic and MapObjects allow this

Contacts

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  (814) 234-8625

VTrans Route Log Assessment

ISLE Application

GIS-T CONFERENCE
April 9-11, 2001

Presented By:
Todd Rottet, Pennsylvania DOT
Brooks Kehler, Pennsylvania DOT

Pa Department of Transportation

Agenda

- Importance of SLD
- Pre GIS
- ISLE Explanation
- ISLE Business Uses
- GIS Prototype
- Broadened Utility (ISLE)
- Demo ISLE application
- Questions

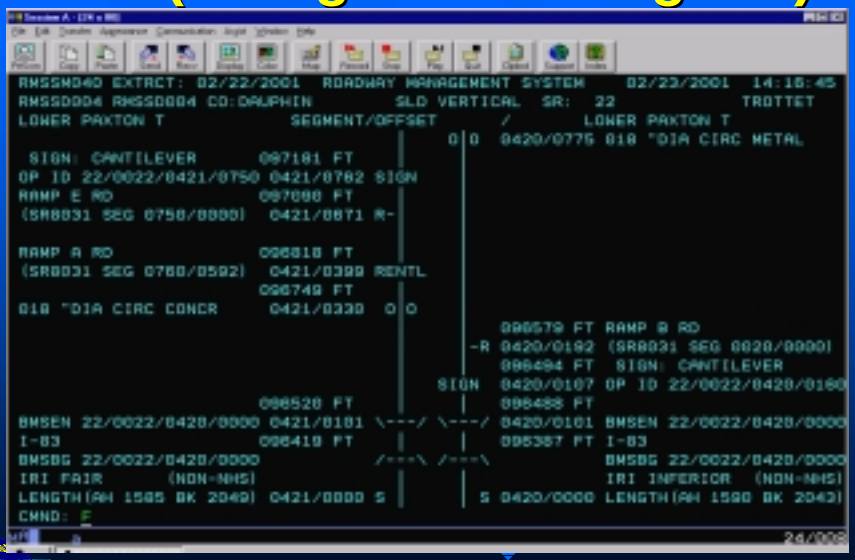
Pa Department of Transportation

Straight Line Diagram (SLD)

- Importance of SLD's
  - –Traditional Graphics Display
    - »Roadway Footages
    - »Feature Attributes
  - –40,000 Miles State Owned

Pa Department of Transportation

SLD (Straight Line Diagram)



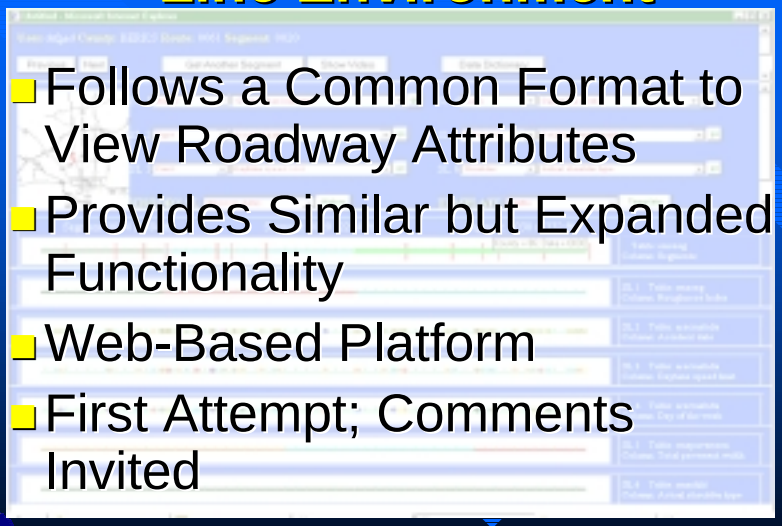
Pa Department of Transportation

Pre GIS - Mainframe SLD

- Data Sets Generally Limited
- Difficult Spatial Reference
- SLD Difficult to Utilize

ISLE Display Screen

(ISLE) Interactive Straight Line Environment



- Follows a Common Format to View Roadway Attributes
- Provides Similar but Expanded Functionality
- Web-Based Platform
- First Attempt; Comments Invited

Potential (ISLE) Business Uses

- Roadway Management
- Bridge Management
- Traffic Monitoring
- Crash Records

GIS-Based Prototype

- Accessible on PennDOT's Intranet
- Demonstrated to District and County Employees
- Modified Design to Meet Customers Needs
- Business Audience Similar to Mainframe SLD

trottet@dot.state.pa.us

Broadened Utility of SLD Application

- Shows Multiple Combinations of Data
- Displays a Graphic Representation
- Provides History Data
- Generates Templates
- Enhances Customer Base

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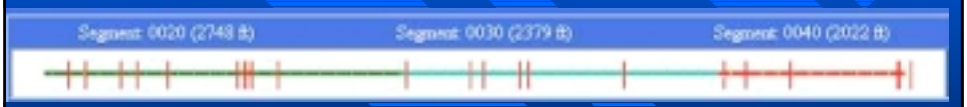
Technical Environment

- GeoMedia WebMap
  - MGE Segment Manager
  - Active Server Pages / JavaScript
- Aggregate Selected Segments
  - Calculate Ratio = (Seg_Length / Graphic Length)



- Create a Distributed Attribute Table
  - –Coordinate File for the Graphic
- Map Attributes Selected
- Data Generated out of temporary DA Table

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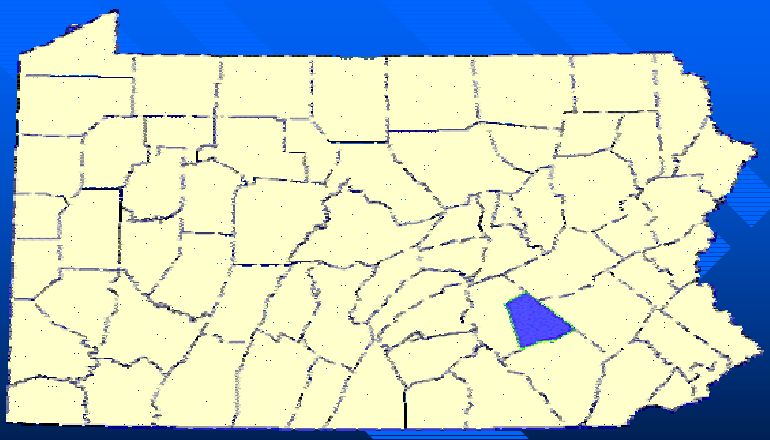
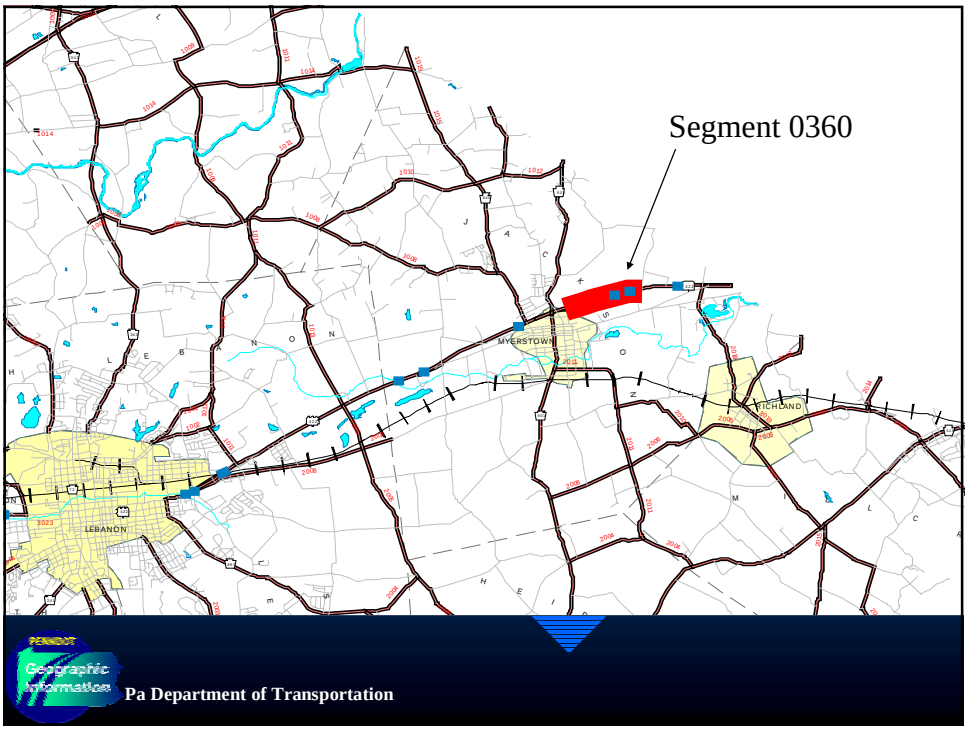
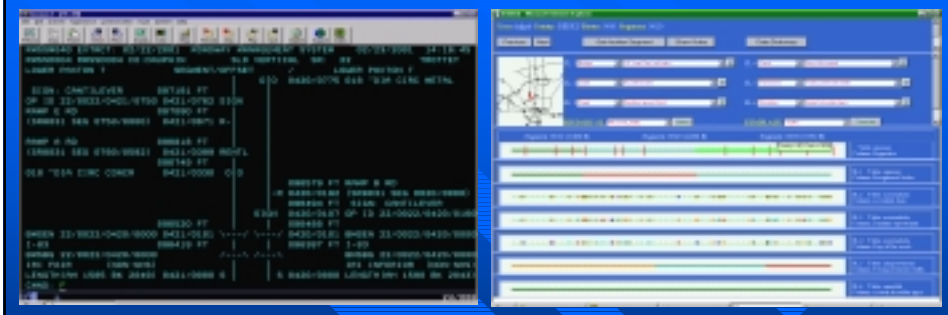
DEMO



Pa Department of Transportation



Conclusion



- Map Multiple Segments
- Customizable Attribute Mapping
- Overview Mapping
- Web Based

PENNDOT Geographic Information Pa Department of Transportation

Questions

Pa Department of Transportation

Straight Line Diagrams
A Decision Support Tool

Jeff Tomlinson
System Consultant
GIS Transportation – Business Development

BRINGING IT TOGETHER.

INTERGRAPH

Needs

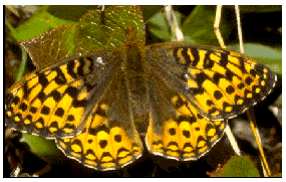
- **Facilitate better management of resources adjacent to the highway system.**
- **Give maintenance and construction managers tools that are useful.**
- **Provide an information database for managers and planners.**

INTERGRAPH
Mapping and GIS Solutions

Needs

Accomplish mission within the constraints of "Key Environmental Regulations"

- **Federal Endangered Species Act**
- **Clean Water Act**
- **National Environmental Policy Act**
- **National Forest Management Act**



INTERGRAPH
Mapping and GIS Solutions

Plan

- **A team of maintenance managers, field staff, and environmental staff reviewed maintenance activity for potential impacts to water quality and developed best management practices (BMPs) to minimize those impacts.**
- **A similar team reviewed maintenance activities for impacts to habitat. This review looked at the impacts that specific maintenance activities could have on habitat and fishery resources that are listed as threatened or endangered under the Federal Endangered Species Act.**

INTERGRAPH
Mapping and GIS Solutions

Maintenance Activities

Surfacing and Shoulder work

Drainage Work

INTERGRAPH
Mapping and GIS Solutions

Maintenance Activities

Bridge Work

Vegetation Control

Snow and Ice Removal

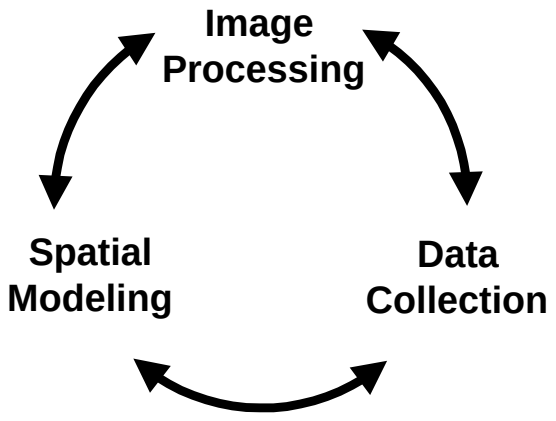
INTERGRAPH
Mapping and GIS Solutions

Objectives

- **Provide information that will enable the agency to accomplish its goal of providing an effective transportation system, while actively protecting the environment.**
- **Provide information to personnel that will minimize the potential for violations of the Federal Endangered Species Act or the Clean Water Act.**
- **Provide information that will improve the ability to work with the National Marine Fisheries Service, the Department of Fish and Wildlife, the U. S. Fish and Wildlife Service, and the U. S. Army Corps of Engineers.**

INTERGRAPH
Mapping and GIS Solutions

Technical Approach



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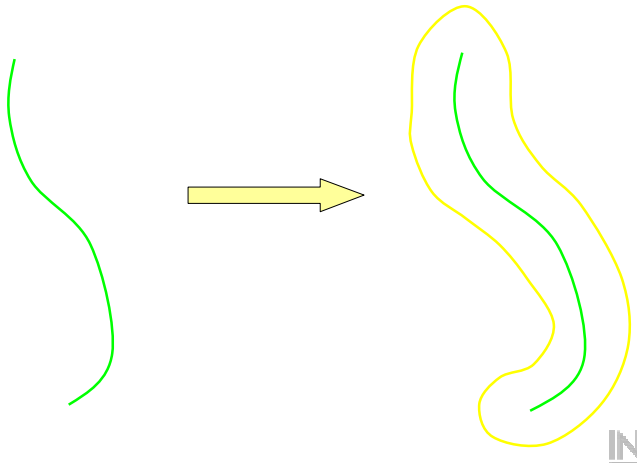
Mapping and GIS Solutions

Field data production

buffer road network to create *"cookie cutter"* for transportation corridor



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Field Verification/Classification

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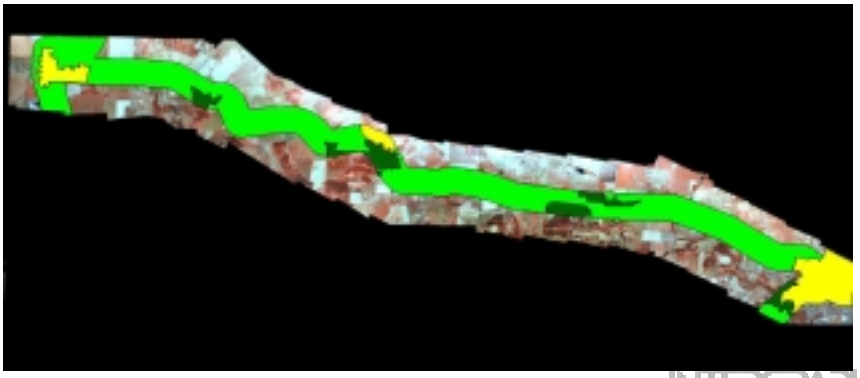
Imagery

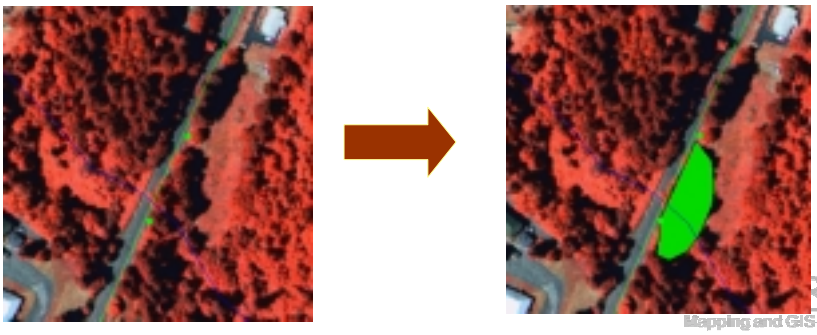
- **Dominant Land cover Type**
  - Agriculture, Urban, Forest, Shrub / Grass, Barren and Water



GIS data

processing field data

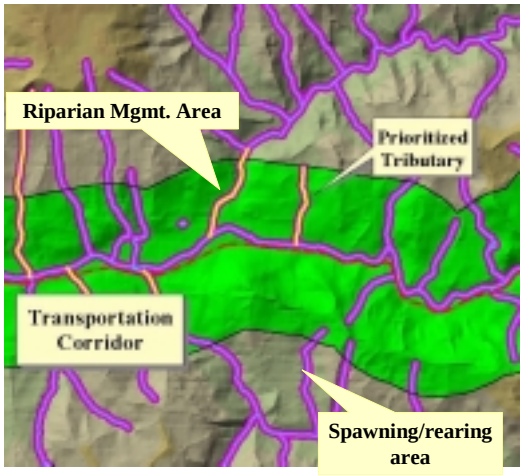
- data returned in GIS format and theme-specific GPS points
- missing themes digitized off imagery using GPS points as guide
- theme elements removed based on field verification



Vegetation Classification

INTERGRAPH
Mapping and GIS Solutions

Modeling



Development of ***field-proven*** modeling rules allows for the collection of data that would be too *costly* to inventory across the entire state

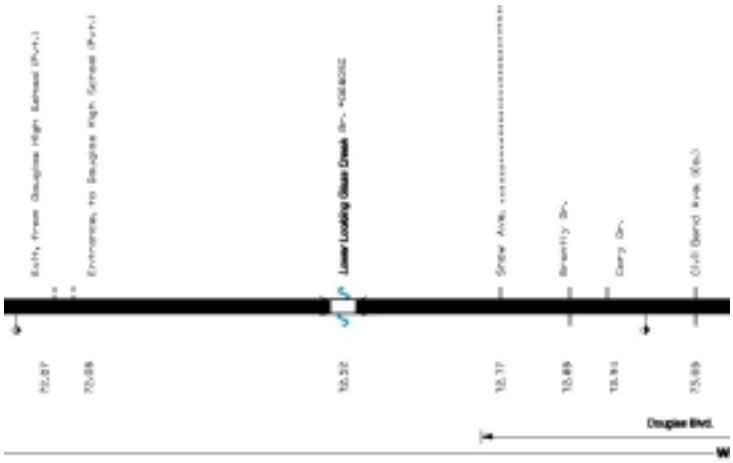
INTERGRAPH
Mapping and GIS Solutions

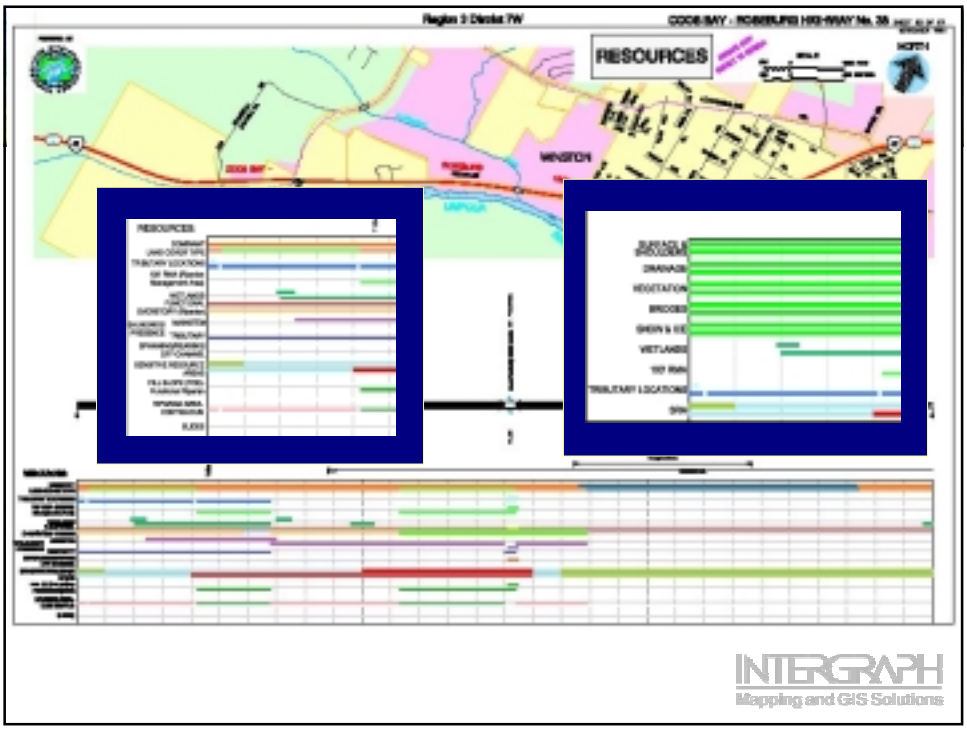
LRS:
"tying" data back to the roads

Export Data to Mapping Program

```
019100100S00 ,1,191,00,L,  10.072,  10.116,    1,02/23/00
019100100S00 ,1,191,00,L,  14.953,  14.992,    1,02/23/00
019100100S00 ,1,191,00,L,  15.036,  15.684,    1,02/23/00
019100100S00 ,1,191,00,L,  16.796,  16.840,    1,02/23/00
019100100S00 ,1,191,00,L,  20.802,  20.870,    1,02/23/00
019100100S00 ,1,191,00,L,  20.956,  20.984,    1,02/23/00
019100100S00 ,1,191,00,L,  21.001,  21.045,    1,02/23/00
019100100S00 ,1,191,00,L,  21.727,  21.733,    1,02/23/00
019100100S00 ,1,191,00,L,  23.053,  23.091,    1,02/23/00
019100100S00 ,1,191,00,L,  23.547,  23.598,    1,02/23/00
019100100S00 ,1,191,00,L,  24.219,  24.268,    1,02/23/00
019100100S00 ,1,191,00,L,  25.389,  25.589,    1,02/23/00
019100100S00 ,1,191,00,L,  25.750,  25.785,    1,02/23/00
019100100S00 ,1,191,00,L,  26.071,  26.088,    1,02/23/00
```

Straightline Map View





Benefits

- **Management System that saved time and money**
- **Used to modify Maintenance Management System to meet requirements of federal law.**
- **Allowed agency to make decisions on daily maintenance activities without having to consult with Federal Agencies**
- **Maps in maintenance vehicles**

INTERGRAPH
Mapping and GIS Solutions

Using the GPS Leader™for Household Surveys and Other Applications

AASHTO GIS-T 2001 - April 10, 2001

Mark Lepofsky, Ph.D.
Manager, Commercial Products
Battelle
202-646-7786 lepofskym@battelle.org

www.battelle.org/transportation
www.gpsleader.com

Battelle
Transportation

1

GPS Leader™
An Innovative Device for Data Collection

- First commercially available GPS-based data collection device for traffic and transportation studies
- Designed for in-vehicle use
- Compact, rugged, highly integrated
- Customizable user interface for different data collection/ survey applications
- Advanced Battelle technology

Battelle
Transportation

2

Battelle's GPS Leader

Package Includes:

- Main unit
- Palm OS PDA
- GPS antenna
- Cables
- Software for downloading and managing data
- Documentation and video

GPS Leader Features

- GPS-based data collection device
- Data collected: (every second)
  - Vehicle location in latitude & longitude (from GPS)
  - Travel speed (from GPS)
  - Driver/occupants and trip purpose data (from handheld user interface)
- Stores 5 to 7 days of detailed trip data for later download/analysis
  - Approximately 70 hours at the one-second level

Applications for In-Vehicle GPS Technology

- Personal or Household Surveys
  - Transportation Planning, Travel Demand Analysis
- Vehicle Activity Surveys
  - Commercial Truck Survey
- Emission Modeling and Duty Cycle Studies
  - Calibration for Microscopic Simulation, Evaluate Engine Stress to Improve Performance
- Travel Time Studies
  - Congestion Management
- Fleet Performance / Operations Analysis
  - Evaluate Driver Behavior, Evaluate Fleet Productivity and Identify Areas of Improvement

Who Can Benefit from GPS Deployment?

- Transportation Planning Agencies
  - All levels: State, Region, County, City, and MPO
  - Collect detailed and accurate travel behavior data unavailable from traditional telephone survey
- Traffic Engineers
  - Automate and improve accuracy in travel time data collection for evaluating traffic signal timing and congestion management
- Commercial and Public Fleet Managers
  - Study fleet performance for improving operations of transit, public vehicles, commercial delivery vehicles, etc.
- Traffic/Transportation Researchers

Household Travel Surveys: Key Benefits

- Determine
  - under-reporting of trips
  - trip rate correction factors
- Improve the accuracy of specific trip elements
  - trip start and finish time
  - origin and destination
  - distance
  - duration
- Obtain data on
  - route choice
  - highway functional class usage
    - time of day, trip purpose, and travel speed

Household Travel Surveys: Important Considerations for Implementation

- Length of deployment
  - multiple days improves accuracy
    - non-driving days
    - day-of-week variations
- Number of vehicles per household
- Device efficiency rate
- Technology bias
- Participant's Primary Language
- Tradeoff between in-vehicle versus multi-modal operation

Household Travel Surveys: Study Implementation

- Recruitment and scheduling
- Device setup and deployment
- Installation and use
- Return of equipment
- Downloading GPS and survey data
- Pre-processing
- Analysis

Household Travel Surveys: Installing the GPS Leader

- Place the antenna outside the vehicle
- Install the power plug (and splitter, if necessary)
- Check to make sure the control unit and PDA are connected
- Place the control unit out of the way

Household Travel Surveys: Entering Data

- Turn on vehicle, then PDA
- Press 'START'
- Never need to enter data while vehicle is in motion

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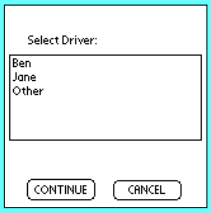
Transportation

11

Household Travel Surveys: Entering Data

- Select driver from pre-populated list
- Select any passengers, if any, from pre-populated list
- Stow PDA and begin driving



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Household Travel Surveys: Entering Data (cont.)

- Stop vehicle and select 'END TRIP'
- Select trip purpose for each occupant (will vary for each survey)
- Indicate whether you are at your final destination or an intermediate stop

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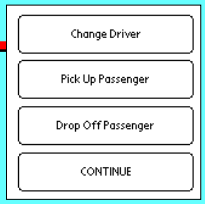
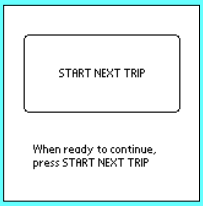
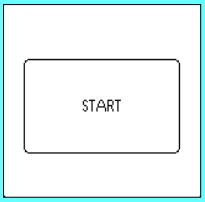
Household Travel Surveys: Entering Data (cont.)

- For intermediate stops, indicate whether
  - there is a change in driver
  - you picked up a passenger
  - you dropped off a passenger
- Otherwise, device is ready for next trip







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Transportation

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Household Travel Surveys: Sample Summary Data

Admin Time: 02/02/01 16:38:54

Device ID: 2 | Timer: 0 min | GPS Sample Rate: 1 sec | GPS Powered: At Power-On | Application: Personal Travel Survey
Source: Ignition | Idle Speed: 6 km/hr | Analog Sample Rate: 0 sec | PDA Powered: At Power-On | Micro Version: 2.00
Idle Time: 30 sec | Idle Sample Rate: 30 sec | GPS Type: Standard | PDA Version: 1.00p

Chain Number	Trip Number	Start Time	End Time	Number of GPS Records: Bad	Good	Speed > Idle	Distance (miles)	Duration (min)	Occupants	Driver Purpose	PDA Trip	Import Flag
1	1	02/02/01 16:38:57	02/02/01 16:39:04	2	0	0	0	0.12			No	0
2	1	02/02/01 19:15:41	02/02/01 19:18:22	29	1	0	0	2.68			No	0
3	1	02/02/01 19:18:24	02/02/01 19:33:33	0	503	462	5.34	15.15	2	5,9	Yes	0
4	1	02/02/01 19:35:28	02/02/01 19:35:53	0	0	0	0	0.42			No	0
5	1	02/02/01 19:35:56	02/02/01 19:41:11	1	150	109	0.69	5.25	3	4,28	Yes	0
6	1	02/02/01 21:04:46	02/02/01 21:05:57	3	16	0	0	1.18			No	0
7	1	02/02/01 21:05:59	02/02/01 21:11:21	0	149	122	0.94	5.37	3	1,2	Yes	0
	2	02/02/01 21:11:30	02/02/01 21:24:02	0	415	382	5.27	12.53	2	7,30	Yes	0
8	1	02/03/01 12:37:56	02/03/01 12:38:45	20	1	0	0	0.82			No	0
9	1	02/03/01 12:38:47	02/03/01 12:51:28	0	365	321	3.5	12.68	3	3,8	Yes	0
	2	02/03/01 12:52:10	02/03/01 14:08:53	11	2869	2858	66.71	76.72	3	5,10	Yes	0
10	1	02/03/01 16:42:24	02/03/01 16:43:06	27	0	0	0	0.7			No	0
11	1	02/03/01 16:43:08	02/03/01 18:47:33	11	1984	1736	28.75	124.42	6	1,2	Yes	0
12	1	02/03/01 18:47:41	02/03/01 18:51:08	0	7	0	0	3.45			No	0
13	1	02/03/01 18:51:10	02/03/01 20:09:31	8	2952	2911	65.26	78.35	3	7,30	Yes	0
14	1	02/04/01 10:15:31	02/04/01 10:19:08	28	16	5	0.04	3.62			No	0
15	1	02/04/01 10:19:10	02/04/01 10:28:38	0	327	299	3.99	9.47	2	10,11	Yes	0
16	1	02/04/01 11:59:38	02/04/01 11:59:58	7	6	0	0	0.33			No	0
17	1	02/04/01 12:00:00	02/04/01 12:11:18	0	402	338	3.98	11.3	2	7,30	Yes	0

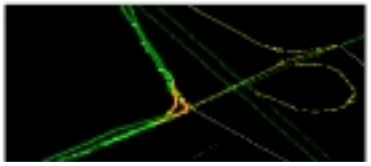
Household Travel Surveys: Matching GPS and Interview Trips

- Sort both by time (and date) of day
- Compare start time, end time, trip duration, and trip distance for pairs of trips
- Use automated statistical algorithms to identify matches
- Analyst visually verifies matches and non-matches
- Create final dataset for statistical analysis

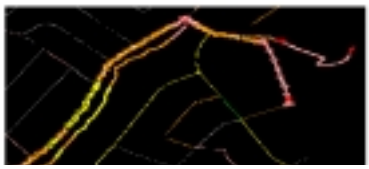
Household Travel Surveys: Analysis

- Develop overall trip rates for the same strata used to define the travel day sampling frame
- Compare these estimates to those based on household interviews
- Using only matched trips, compare estimates of travel times and trip distances and possibly vehicle occupants and trip purpose
- Develop recommended adjustment factors for trip rates, trip distance, and travel time

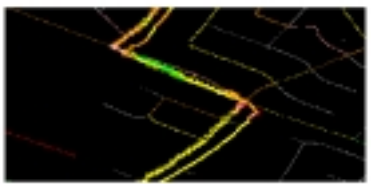
Examples of Map-Matched Travel Data

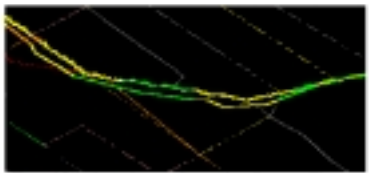


map-matching improves accuracy, allowing distance calculations using the road network rather than the GPS points



requires careful attention at trip ends or where the road network does not exist





Vehicle Activity Surveys

- Unobtrusive data collection without the handheld unit
- GPS Leader senses vehicle ignition
- Powered by vehicle – don't have to worry about running down internal batteries
- Large data storage capacity can handle long-distance trips
- Allocate vehicle location properly to
  - air basins, counties, urban areas

Travel Time Studies

- Systematic deployment on the local or regional transportation network for congestion management
- Identify specific points of delay and congestion
- Aggregate travel times on specific roadway segments
- Increase use at different periods (e.g., morning and afternoon peaks) for more detailed estimates
- More accurate than stopwatch method and does not require two people for data collection

Emission Modeling and Duty Cycle Studies

- Can measure:
  - starts and stops
  - acceleration and deceleration
  - cruising speeds
- Understand how vehicle activity contributes to airborne emissions
- Understand how vehicles are typically driven to better understand issues relating to wear and tear
- Event port can receive data from external sensor (e.g., direct emissions measurement)

Fleet Performance/Operations Analysis

- Cheaper to rotate units among the fleet than to purchase and permanently install expensive telematics systems
- Understand:
  - how vehicles are typically being driven
    - speeds, aggressive starts and stops, etc.
  - how drivers choose their routes and other behavior